USDA

United States Department of Agriculture

FISHLAKE NATIONAL FOREST

MID-LEVEL EXISTING VEGETATION CLASSIFICATION AND MAPPING

January 2018

FISHLAKE
NATIONAL FOREST

Forest Service

Intermountain Region

(This page intentionally left blank)

Table of Contents

Table of Figures

Table of Tables

(This page intentionally left blank)

Executive Summary

Existing vegetation classification, mapping, and quantitative inventory (VCMQ) products for the Fishlake National Forest (FNF) were developed to help better understand the spatial distributions of vegetation types, structural classes, and canopy cover. These products were developed collaboratively with the FNF, the Geospatial Technology and Applications Center (GTAC) (formerly known as the Remote Sensing Application Center (RSAC)), the Intermountain Regional Office (RO), and the Interior West Forest Inventory and Analysis (IWFIA) program. The final maps align with the Existing Vegetation Classification, Mapping, and Inventory Technical Guide (Nelson et al. 2015). The vegetation maps comprise 25 vegetation type map units, five tree canopy cover classes, three shrub canopy cover classes, five forest tree size classes, and four woodland tree size classes. An accuracy assessment was completed to help users quantify the reliability of the map products and support management decisions that may use this information. The existing vegetation products discussed in this document will help users to better understand the extent and distribution of vegetation characteristics for mid-level planning purposes, and disclose the methods and accuracies of these products. The FNF mid-level existing vegetation project is one among many VCMQ projects currently being completed in the Intermountain Region.

Introduction

Existing vegetation classification, inventory, and mapping was completed on the Fishlake National Forest (FNF) in Utah to standards established by the Intermountain Region Vegetation Classification, Mapping, and Quantitative Inventory (VCMQ) team and outlined in the Existing Vegetation Classification, Mapping, and Inventory Technical Guide (Nelson et al. 2015). The purpose of the project was to provide current and complete information about vegetative communities, structure, and patterns across the FNF landscape. Fulfilling this purpose is important in measuring compliance with National Forest Management Act (NFMA) obligations, such as providing for a diversity of vegetation and associated habitat for terrestrial wildlife species.

Some resource management applications of the existing vegetation products may include ecosystem and wildlife habitat assessments, rangeland and watershed assessments, fuel load assessments, benchmark analysis, range allotment management plan updates, threatened and endangered species modeling, and recreation management. This document provides an overview of the methods, products, and results of classification, inventory, mapping, and accuracy assessment activities that were completed for the FNF.

Region 4 VCMQ Objectives

The Intermountain Region (Region 4) has identified the development of vegetation map products and associated inventory and classification work as one of its highest priorities since 2008. The goal of this effort has been to facilitate sustaining or restoring the integrity, biodiversity, and productivity of ecosystems within the Region by providing a sound ecological understanding of plant communities and their composition and structure.

Specific goals are to:

1. Help Forests continue to manage the lands according to their land management plans,
2. Provide the public with an initial classification, inventory, and map of mid-level existing vegetation in the Intermountain Region,
3. Establish a baseline of landscape ecological conditions, including vegetation type, tree size, and canopy cover distributions and locations throughout the Intermountain Region,

4. Establish consistent methodologies and standardized data that meet best available science requirements, eliminate redundancies, leverage consistency, save money, and establish a framework for future activities,
5. Develop scientifically credible products that meet business requirements at multiple scales and for multiple purposes, and
6. Develop an update and maintenance program to ensure decisions are made based on the best available information.

Intended Uses

The products discussed in this document can be used to address a variety of important land management issues related to watersheds, forest characteristics, rangelands, fuel loads, and wildlife habitat. Feasible applications include resource and ecosystem assessments, species habitat modeling, benchmark analysis, design of monitoring procedures, and a variety of other natural resource analysis applications. Specifically for the FNF, the products will be useful for habitat assessments, grazing analyses, planning large-scale fuel reduction projects, landscape-level post-fire restoration projects, providing information to the public, and Forest Plan revisions. These products may provide information for targeting areas requiring investigation for potential projects or determining where more detailed studies are needed. Additionally, data collected during this effort may feed into broader-level analyses, such as determining estimates of nation-wide biomass, analyzing climate change responses, or mapping land cover.

Business Needs Requirements

The development of existing vegetation classification, inventory, and map products is at the heart of our Agency's mission (http://www.fs.fed.us/about-agency/what-we-believe):

> The mission of the Forest Service is to sustain the health, diversity, and productivity of the nation's forests and grasslands to meet the needs of present and future generations.

Our mission, as set forth by law, is "to achieve quality land management under the sustainable multiple-use management concept to meet the diverse needs of people." One mission activity that is directly related to the development of vegetation products is identified as "developing and providing scientific and technical knowledge aimed at improving our capability to protect, manage, and use forests and rangelands." The Guiding Principles employed to align this mapping project with our agency's mission and vision, include:

1. Use an ecological approach to the multiple-use management of the National Forests and Grasslands, and

2. Use the best scientific knowledge in making decisions and select the most appropriate technologies in the management of resources.

More recent Forest Service initiatives strengthen the need for acquiring existing vegetation information for our Forests and Grasslands. The National Forest System Land Management Planning Rule (36 CFR Part 219) Subpart A—National Forest System Land was published in the Federal Register on April 9, 2012, and became effective 30 days following the publication date. The new planning rule establishes “ecological sustainability” as a primary objective in forest management, and addresses “conservation of water flow and assurance of a continuous supply of timber as set out in the Organic Act, and the five objectives listed in the Multiple-Use Sustained Yield Act of 1960 (Public Law 86-517): outdoor recreation, range, timber, watershed, and wildlife and fish.”

Included in the new planning rule regulations, the plan monitoring program addresses the applicability of eight requirements per 36 CFR 219.12(a) (5). The FNF’s existing vegetation effort addresses three of the eight plan monitoring program requirements: 1) the status of select watershed conditions, 2) the status of select ecological conditions including key characteristics of terrestrial and aquatic ecosystems, and 3) the status of a select set of the ecological conditions required under §219.9 to contribute to the recovery of federally listed threatened and endangered species, conserve proposed and candidate species, and maintain a viable population of each species of conservation concern.

The 2012 planning rule also requires the responsible official to use the “best available scientific information” to inform the assessment, the development of the plan (including plan components), and the monitoring program. The planning rule requires that responsible officials document how the best available scientific information was used.

More recently, the Forest Service has developed a strategy for inventory, monitoring, and assessment (IM&A) activities as directed in the Forest Service Manual (FSM-1940). The strategy establishes a comprehensive approach for conducting IM&A activities in the agency that responds to our priority business requirements. The IM&A strategy lists existing vegetation as a sidebar for the strategy, and includes the statement “Existing vegetation, for example, is the primary natural resource managed by the Forest Service and is the resource on which the agency spends the most money for inventories and assessments” (USDA Forest Service 2013).

The FNF existing vegetation mapping project attempts to meet the requirements, policy, and guidelines for properly managing our forests through standardized protocol development and implementation, data standardization, reliable data processing, defensible methodologies, and full disclosure. These policies, guidelines, and requirements establish the collection of existing guidance for proper land management in the area. The goal of the vegetation information and mapping products is to effectively meet the needs of resource managers, fulfill the Forest Service mission, vision and comply with current guidance.

General Characteristics of the Area

The Intermountain Region of the Forest Service encompasses nearly 34 million acres of the National Forest System lands. The Intermountain Regional Office in Ogden, Utah, provides administrative support for the Region's National Forests and Grasslands. This region contains 12 Forests in the states of Idaho, Utah, Nevada, Wyoming, Colorado, and California where four major geographic provinces, Great Basin, Colorado Plateau, Northern Rocky Mountains, and Middle Rocky Mountains, come together.

The FNF spans about 1.5 million acres in south-central Utah (Figure 1). The Forest is comprised of the Fillmore, Fremont River, Beaver, and Richfield Ranger Districts. The Forest Supervisor's Office is located in Richfield, Utah.

The Bonneville Basin, Northern Canyonlands, and Utah High Plateau Ecomap Sections compose the FNF. These ecological sections are comprised of sedimentary, sandstone, shale and volcanic rocks, with steep-sided canyons, plateaus, and mountains formed by faulting (McNab et al. 2007). Elevations on the forest range from 4,700 to 12,169 feet. Desert shrubs, sagebrush, rabbitbrush, and pinyon-juniper vegetation dominate lower and mid-elevations, while aspen, spruce, fir, and pine dominate at higher elevations. Approximately two-thirds of total precipitation on this Forest falls between October and April. Winter and spring storms originate from the Pacific Northwest, while late summer and early fall storms move in from south-southwest (USDA Forest Service 1986).

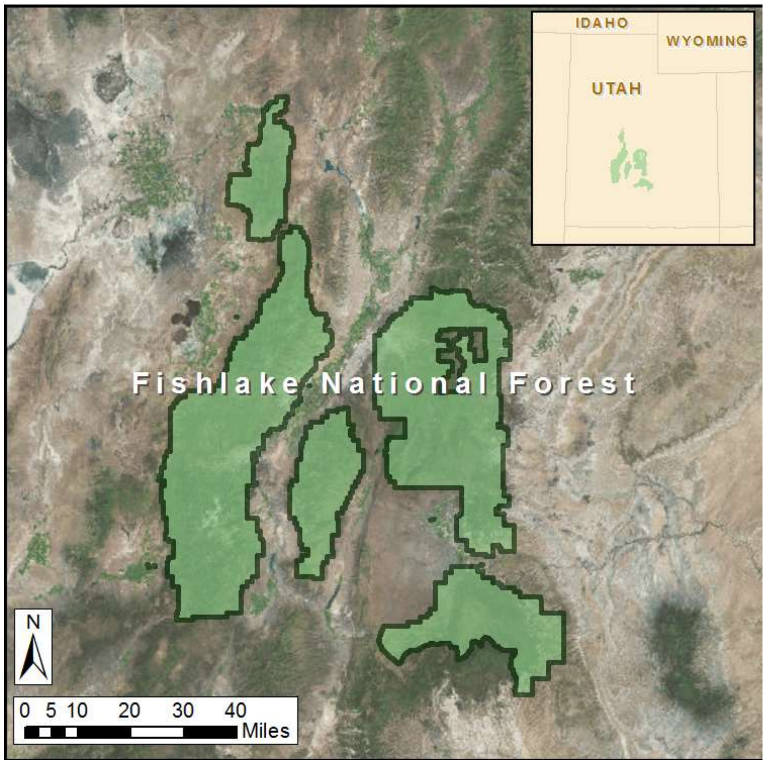


Figure 1: The Fishlake National Forest, located in southern-central Utah.

Partnerships

The mid-level vegetation products were collaboratively planned, developed, and implemented by technicians and experts within the Forest Service. These partnerships were critical to ensure the highest level of integrity, objectivity, and usefulness for internal uses and for external consumption. The primary participants in the development included FNF and Regional Office staffs, the Geospatial Technology and Applications Center (GTAC) (formerly known as the Remote Sensing Applications Center (RSAC)), and the Interior West Forest Inventory and Analysis (IWFIA) Program of the Rocky Mountain Research Station (Figure 2).

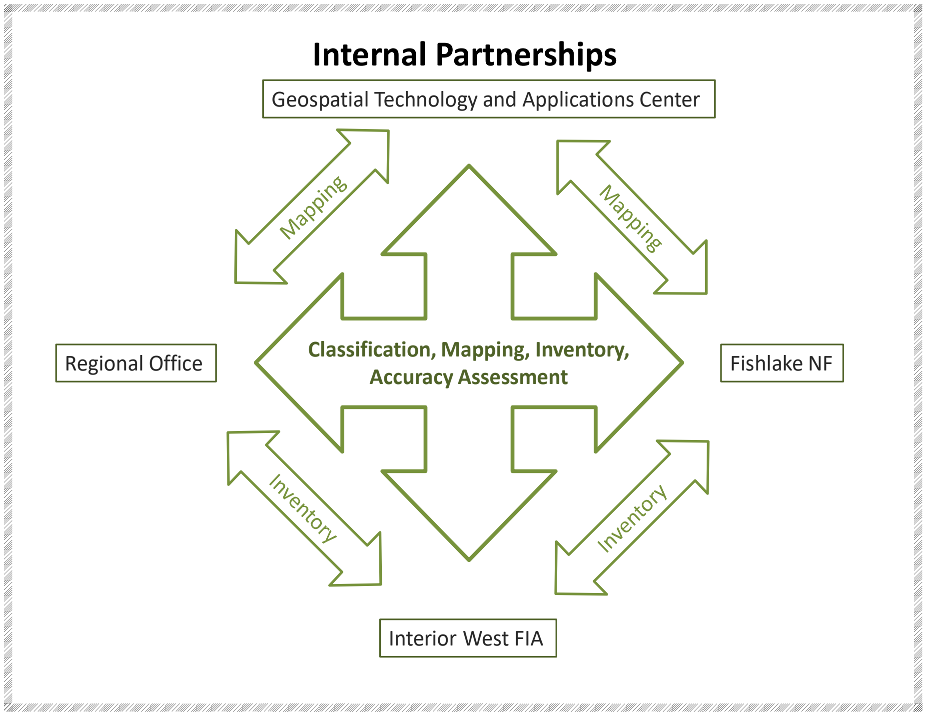


Figure 2: Partnerships developed for the classification, mapping, inventory, and accuracy assessment conducted on the FNF.

The Intermountain Regional Office established the VCMQ core team in 2009 to create vegetation products for regional and forest-level uses, such as forest-planning-level analysis, broad-scale analysis, monitoring, assessments, and as a framework for project-level analysis. The team provides expertise in botany, ecology, forestry, soils, remote sensing, inventory and mapping, GIS, information technology, and program management.

The FNF is a primary stakeholder in the derived outcomes of this project, since they administer the lands and use these products for land management activities. The FNF has collaborated on all aspects of the vegetation mapping project from the initial needs assessment to the final accuracy assessment. A focused group of forest resource specialists, contract specialists, and GIS specialists helped identify tasks and deliverables, made recommendations based on user needs, and served as Forest representatives to the collaborative effort. A broader audience of resource specialists and program managers reviewed draft map products, provided field-based knowledge, and offered suggestions to make the deliverables more meaningful from a Forest perspective.

GTAC is a national technical service center of the USDA Forest Service. The mission of GTAC is to provide the Forest Service with the knowledge, tools, and technical services required to use remote sensing data to meet the Agency's stewardship responsibilities. GTAC's Mapping, Inventory, and Monitoring program provides operational remote sensing support and analysis services to help meet internal and interagency programmatic assessment and monitoring needs, such as this existing vegetation mapping project. GTAC is the principal provider of remote sensing technical expertise and map production techniques for this effort. The Center has assisted in this effort in all aspects: data collection, remote sensing analyses, image segmentation, image analysis, field reference data protocol and sample design, map filtering, map production, draft map reviews, and final report development.

The IWFIA unit operates under technical guidance from the Office of the Deputy Chief for Research and Development, located in Washington, DC, and under administrative guidance from the Director of the Rocky Mountain Research Station located in Fort Collins, Colorado.

This research unit provides ongoing support for the inventory aspects of the project: IWFIA inventory on forest land and all-condition inventory (ACI) on non-forest plots, contract inspections, data collections, database assistance, pre-field inspections, intensified inventory sample design, and accuracy assessment. Their participation ensures consistency and establishes credible and defensible inventory data to be used in conjunction with the derived map products.

Final Products

The final map products depict continuous land cover information for the entire project area including the FNF and private land inholdings. Note that vegetation data for the southern part of the Fremont River Ranger District, which was formerly the Teasdale Ranger District of the Dixie National Forest, was modeled during the Dixie National Forest (DNF) mapping effort, and may be found in the DNF VCMQ mid-level map products. Maps are formatted as a geodatabase, which is compatible with Forest Service corporate GIS software. The vegetation maps are consistent with mid-level mapping standards set forth in the Existing Vegetation Classification, Mapping, and Inventory Technical Guide (Nelson et al. 2015). In compliance with these standards, upland modeling units were aggregated up to five acres and riparian vegetation types were aggregated to two acres. Additional products include field-collected reference information and photographs, seasonal Landsat image mosaics and derived vegetation indices, topographic derivatives, climate data, and fire history information.

Methods

The phases for this project included project planning, data acquisition and processing, classification development, segmentation, map unit legend design, reference data collection, modeling, draft map review and revision, and final map development (Figure 3). After the final maps were completed, an accuracy assessment, vegetation type map unit description, and dominance type descriptions were developed.

Maps depicting existing vegetation types, canopy cover, and tree size classes were developed using moderate and high resolution imagery, topographic data, ancillary GIS layers, field and photo-interpreted reference data, automated image segmentation, and data-mining classification techniques. The remotely sensed imagery assembled for this project included moderate and high resolution satellite and aerial imagery. Twenty-two Landsat scenes (30-meter spatial resolution) were assembled depicting spring, summer, and fall conditions. The high resolution imagery included 2011 and 2014 National Agricultural Imagery Program (NAIP) aerial photography (1-meter). U.S. Geological Survey Digital Elevation Models (DEM) (10-meter) were compiled. Other ancillary GIS layers that were gathered include climate, wildfire perimeters, Field Sampled Vegetation (FSVeg) existing vegetation database, USGS National Land Cover Database 2011 (NLCD), USGS GAP Land Cover Data, and interferometric synthetic aperture radar (IfSAR) data (Appendix A).

Vegetation indices and image transformations were generated from Landsat and high resolution imagery while topographic information was derived from the digital elevation models (Appendix B). All imagery and topographic derived information were projected to a common geographic coordinate system (UTM, NAD83, Zone 12 N). Modeling units (image segments) were developed using 2013 Landsat data, 2011 NAIP imagery, and a topographic derivative.

Field sites were collected in homogeneous modeling units during the summer of 2014, 2015, and 2016 with information on vegetation composition, canopy cover, and tree size recorded. Additional canopy cover reference information was obtained using photo interpretation methods.

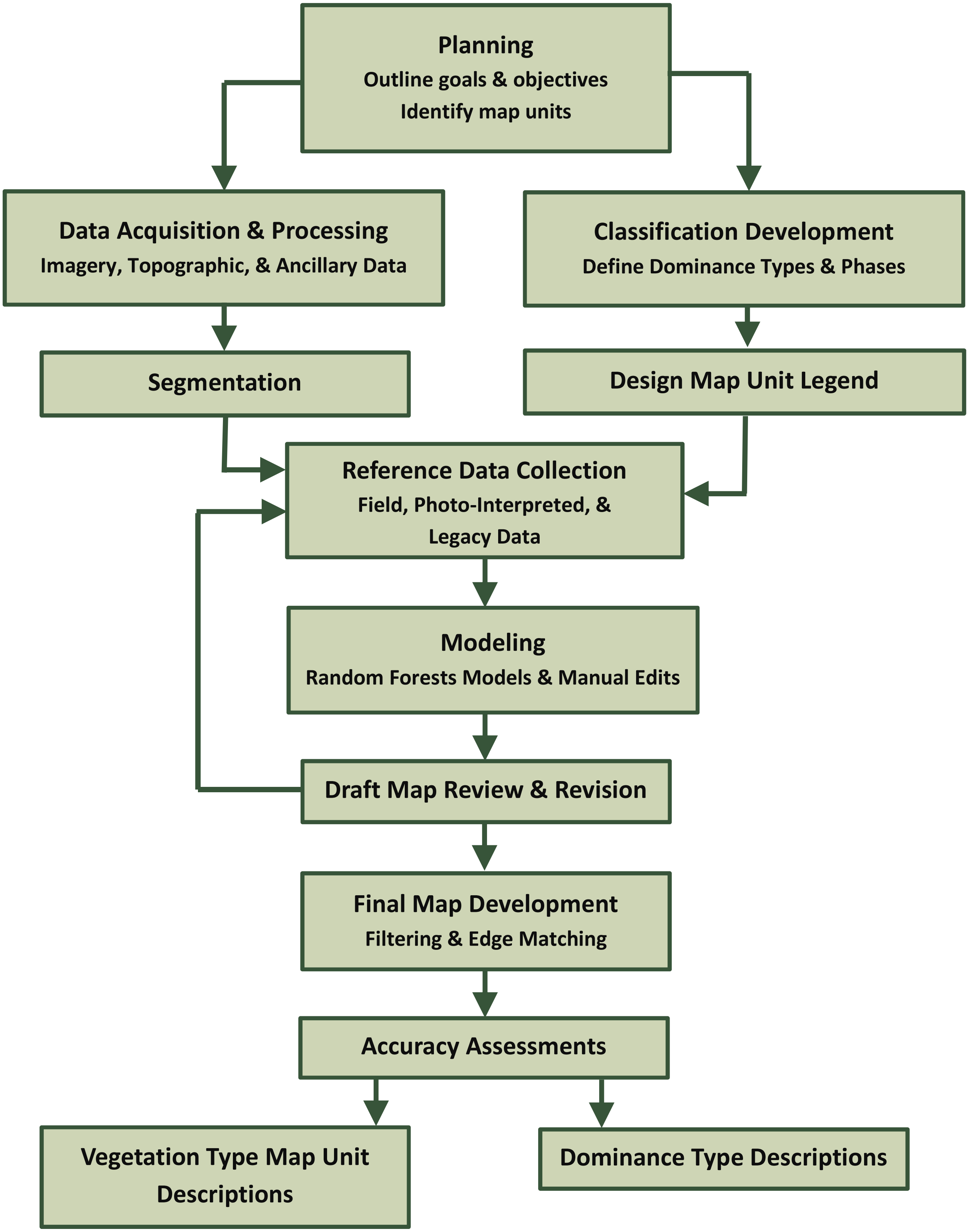


Figure 3: Project phases from project planning to descriptions of vegetation type map units and dominance types.

Map unit labels (vegetation type, canopy cover class, and tree size class) were assigned to the modeling units using Random Forests (Breiman 2001). Random Forests is a method of automated computer classification and regression that uses reference and geospatial data to develop decision trees. Each map (vegetation type, canopy cover class, and tree size class) was developed individually using distinct reference data sets and geospatial data layers.

Draft maps were distributed to FNF resource specialists for review and final revisions were made based on their feedback. Maps were completed by aggregating and filtering the modeling units to the minimum map feature size. Upland vegetation types were filtered to five acres, while riparian vegetation types were filtered to two acres. An accuracy assessment was conducted and descriptions of the vegetation type map units were written.

Project Planning

In 2014, staff of the FNF, Intermountain Regional Office, and GTAC met to discuss map unit design and prepare a project plan. Since one of the goals for the project was to provide a regionally cohesive map product, efforts were made to ensure that methods and spatial and thematic characteristics of the maps would fulfill regional requirements. A classification of dominance types and phases was developed to address forest information needs. These were combined into vegetation types that achieved a balance between map detail and accuracy within the allocated budget and time constraints. The final vegetation type map units conformed to the mid-level mapping standards referenced in the Existing Vegetation Classification, Mapping, and Inventory Technical Guide (Nelson et al. 2015), while the canopy cover and tree size map units were selected to represent the management needs of the Forest.

Vegetation Classification Development

The Intermountain Region's VCMQ program is designed to classify, map, and quantitatively inventory existing vegetation across the Region. At the regional level, existing plant communities are assigned to dominance types based on the most abundant species of the ecologically dominant life form (e.g., the most abundant tree species in forests or woodlands). This approach was decided upon by a council with representatives from each Forest in the Region.

At the Forest level, the regional dominance types may be subdivided into dominance type phases based on associated species of the same life form as the dominant species. Forests are able to define these phases to best meet their own information needs, as long as they nest within the regional dominance types.

An initial list of dominance types was compiled using Forest vegetation legacy plot data, Forest Inventory and Analysis (FIA) plot data, and vegetation classification literature relevant to the Forest. This list was reviewed and augmented by Forest resource specialists and local contributors. Forest specialists determined whether any dominance types should be split into phases and how those should be defined. Rules for distinguishing phases were tested using the regional plot database and a taxonomic key to dominance types and phases was developed. In practice, phases have only been defined in forests and woodlands, not shrublands or herblands.

Vegetation Type Map Units

Once the classification was developed, Forest and Regional specialists developed a map legend by determining which dominance types and phases should be mapped individually and identifying which dominance types and phases could be combined. Overall map accuracy decreases as the number of map units increases; therefore, the team sought to balance map detail versus map quality. This process was informed by applying the Forest dominance type key to FIA plot data and estimating the acreage of each type on the Forest. The initial map legend was complete when each dominance type and phase was assigned to a map unit and included in the dominance type key. This process was followed to develop the dominance type classification and vegetation type map legend for the Fishlake NF (Tart et al. 2018; Appendix C). Data collected for classification of habitat and community types (Pfister 1972; Youngblood and Mauk 1985; Mueggler 1988; Padgett et al. 1989, West et al. 1998), FSveg data, and plot data collected by the Fishlake NF and Utah Division of Wildlife Resources were used to compile a list of dominance types and test definitions of phases (Table 1).

Table 1: Legacy data sources and associated plot information used for developing dominance type classifications and the mapping process on the Fishlake NF.

Data Set	No. of Dominance Type Classification Plots	No. of Dominance Type Classification Plots with Accurate Georeferencing within FNF boundary
Habitat Type Plots		
Pfister 1972	24	0
Youngblood and Mauk 1985	65	65
Community Type Plots		
Mueggler 1988	130	0
Padgett et al. 1989	40	39
West et al. 1998	16	4
Other Plots		
Fishlake NF Sagebrush	13	12
Fishlake FSveg	24	23
Fishlake NF Range Monitoring	34	34
UT DWR Range Monitoring[1]	37	26
Total	**383**	**203**

[1] Data available at https://wildlife.utah.gov/range-trend.html.

Structural Characteristics

Structural groups for tree size and tree and shrub cover were identified by FNF resource specialists to meet technical requirements specified in the land and resource management plans (Forest Plans). Tree size and canopy cover groups were established to represent a diversity of vegetation structure and density classes appropriate for informing management and maintenance of physical and biological processes. The identified classes facilitate the assessment and monitoring of forest and non-forest vegetation, ecological patterns, processes, and wildlife habitat.

Tree Size Class

Tree size class or tree diameter class is any interval into which a range of tree diameters may be divided for classification (Helms 1998). Tree size is represented by the plurality of a given class forming the uppermost canopy layer as viewed from above. Tree size classes (Table 2) for the Conifer Forest and Deciduous Forest vegetation group map units and the Woodland vegetation group map unit differ in individual diameter class breaks. Forest species are measured using diameter at breast height (DBH) (4.5 feet above the ground) and designated woodland species (Table 3) are measured using diameter at root collar (DRC). Specific procedures used for measuring DRC are found in the Field Reference Data Collection Guide (Appendix D).

Table 2: Tree size map classes represented by diameter at breast height (DBH) for Conifer Forest and Deciduous Forest vegetation group map units, and by diameter at root collar (DRC) for Woodland vegetation group map units.

Forest Tree Size DBH (in)	Code	Woodland Tree Size DRC (in)	Code
0 – 4.9”	FS1	0 – 5.9”	WS1
5 – 11.9”	FS2	6 – 11.9”	WS2
12 – 17.9”	FS3	12 – 17.9”	WS3
18 – 23.9”	FS4	≥18”	WS4
≥ 24”	FS5		

Table 3: Designated woodland species measured by diameter at root collar (DRC).

Species Abbreviation	Scientific Name	Common Name
ACGR3	*Acer grandidentatum*	bigtooth maple
CELE3	*Cercocarpus ledifolius*	curlleaf mountain mahogany
JUOS	*Juniperus osteosperma*	Utah juniper
JUSC2	*Juniperus scopulorum*	Rocky Mountain juniper
PIED	*Pinus edulis*	two-needle pinyon
PIMO	*Pinus monophylla*	singleleaf pinyon
QUGA	*Quercus gambelii*	Gambel oak

Tree and Shrub Canopy Cover Class

Canopy cover represents the total non-overlapping canopy in a delineated area as viewed from above (Nelson et al. 2015). Overlapping canopy not visible from above is not assessed or counted. Map classes representing total tree and total shrub cover from above are listed in Table 4.

Table 4: Map classes for total tree and shrub canopy cover as viewed from above.

Total Tree Canopy Cover	Code	Shrub Canopy Cover	Code
10 – 19%	TC1	10 – 24%	SC1
20 – 39%	TC2	25 – 34%	SC2
40 – 49%	TC3	≥ 35%	SC3
50 – 59%	TC4		
≥ 60%	TC5		

Geospatial Data Acquisition and Processing

Geospatial data acquisition is a major activity in most vegetation mapping efforts that use digital image processing methods. This activity involved assembling remotely sensed images of various spatial and spectral resolutions and an array of geospatial data (Appendix A). A requirement of the mapping process was that any data layer used must be available across the entire FNF to ensure consistency. Data used included imagery from the National Agriculture Imagery Program (NAIP), topographic data in the form of Digital Elevation Models (DEMs), burn perimeters from the Monitoring Trends in Burn Severity (MTBS) program, average annual climate conditions over the most recent three full decades (1981-2010) generated by the PRISM Climate Group, interferometric synthetic aperture radar (IfSAR) data, and 22 orthorectified Landsat 8 OLI satellite images from 2013 and 2014. In addition, enterprise data such as USFS administrative boundaries, land ownership, roads, trails, hydrology, and existing vegetation maps were provided by the FNF.

For modeling purposes only, the FNF administrative boundary was buffered by 0.25 mile to account for edge effects that can occur along the clipped edge of some topographic and image data sources that may negatively impact the classification models. The buffered area was not included in the final map deliverables. Private and state lands contained within the FNF administrative boundary were included in the project area to maintain spatial contiguity and are part of the final map deliverables. However, few field reference sites were gathered within these areas.

All geospatial data, including ancillary GIS layers, remotely sensed images, and topographic layers were projected to the UTM (Zone 12 N, GRS 1980, NAD83) coordinate system and clipped to the buffered project area.

Imagery

All Landsat imagery was co-registered and obstructions (e.g., haze, clouds, cloud shadows) were removed and replaced to develop three seamless seasonal mosaics: spring, summer, and fall. A regression technique was used to replace clouds and cloud shadows and create seamless mosaics between neighboring Landsat scenes. Model II regression is a statistical technique that uses a common area between two images (i.e., overlap between adjacent Landsat scenes) to develop a regression model for each of the spectral bands on the image. The regression equation is then used to “fit” the target image to the reference image by adjusting the pixel values in the non-overlap areas to facilitate the creation of a seamless mosaic between images. Two spectral transformations (Tasseled Cap Transformation and Principal Component Analysis) and one spectral index (Normalized Difference Vegetation Index (NDVI)) were produced from the final Landsat mosaics. A time series of Landsat data was used to generate harmonic regression coefficients to exploit the seasonal trends that occur between different vegetation communities.

The 2011 and 2014 1-meter NAIP images were resampled to 10 meters and mosaicked. This step increased the processing efficiency of image segmentation by reducing the resulting segment file size while still maintaining image resolution appropriate for mid-level mapping. NDVIs were produced using the visible and near infrared bands.

Digital Elevation Models (DEMs) and Topographic Derivatives

Topographic derivatives including three slope and aspect based products (slope, slope-aspect (cos), and slope-aspect (sin)), were developed from the 10-meter DEM (Ruefenacht 2014), as well as heatload, trishade, and valleybottom. Such topographic models are used in the modeling process to depict environmental parameters that help predict vegetation cover types.

IfSAR Data

Interferometric synthetic aperture radar (IfSAR) data estimates vegetation height by taking the difference between two radar returns with different wavelengths. One wavelength returns to the sensor after contact with the ground, and the other wavelength returns to the sensor after coming in contact with vegetation. IfSAR difference products were used for the mapping of tree size class, since tree diameter may correlate with tree height.

Segmentation

Image segmentation is the process of partitioning digital imagery into spatially cohesive polygonal segments (modeling units) that represent discrete areas or objects on a landscape

(Ryherd and Woodcock 1996). The goal of developing segments is to simplify complex images comprised of millions of pixels into more meaningful and mappable objects. Excluding water bodies, the final segments (modeling units) ranged in size from 0.04 to 267 acres with an average size of approximately 3.9 acres.

Modeling units were produced using Trimble eCognition's multi-resolution segmentation algorithm (Figure 4). This algorithm is a bottom-up segmentation technique, whereby pixels are recursively merged together based on user-defined heterogeneity thresholds to form discrete image objects. The input data layers used to generate segments included the resampled NAIP imagery (raw bands and NDVI), Landsat imagery (1st principal component), and trishade topographic data. There are four primary parameters within eCognition's multi-resolution segmentation algorithm that control the spatial and spectral quality of the resultant segments: layer weights, scale, shape, and compactness. Layer weights control the relative influence each of the raster data layers have on the segmentation process (Appendix E).

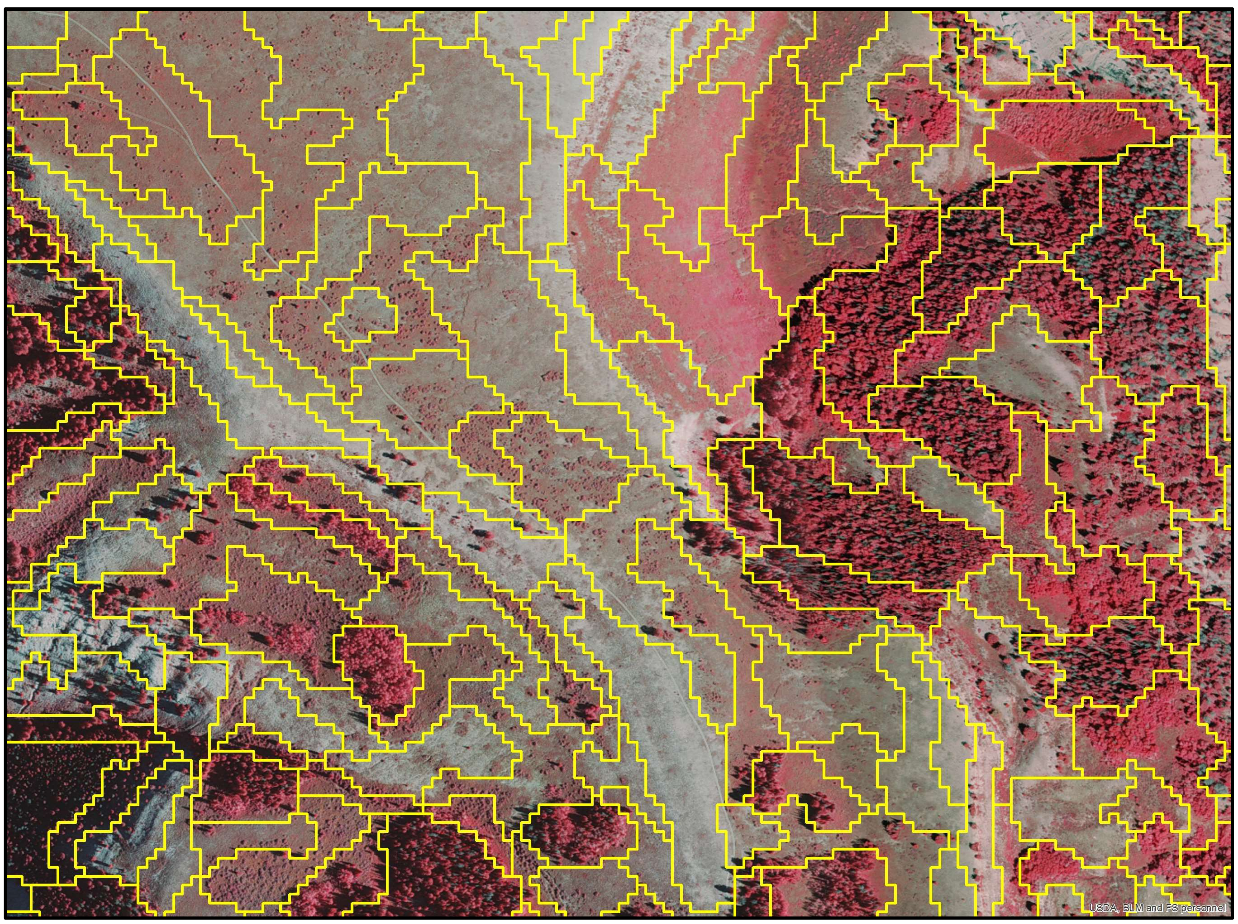


Figure 4: An example of modeling units generated using eCogniton software overlaid on false color 1-meter 2014 resource imagery.

The majority of the influence was given to the 10-meter NAIP imagery. While all layers contribute valuable information to the segmentation process, the “texture” of the higher-resolution, multi-spectral data is often most effective at distinguishing between distinct vegetation types and conditions.

Scale is a unit-less parameter that controls the amount of allowable heterogeneity within segments. Scale parameters can range from 1 to infinity, where the low end would delineate polygons only around identical pixels and the high end would result in the entire study area delineated as a single polygon. As such, scale can also be seen as a proxy control for segment size. A high scale parameter means more heterogeneity is allowed within segments and will ultimately result in larger relative segment sizes. Conversely, a small scale parameter means less heterogeneity is allowed within segments, so smaller segments will result. A scale parameter of 16 was used for the FNF segmentation. The appropriate scale factor was determined by experimentation and previous experience with other Forests.

The shape parameter controls the type of heterogeneity contained within the resultant segments. It is a relative value that caters to the desire for resultant segments to be controlled by spatial homogeneity (shape) and/or spectral homogeneity (color). The values range from 0.0 (a low shape parameter/high color parameter) to 0.9 (a high shape parameter/low color parameter). Segments created with a low shape parameter will have very spectrally homogeneous segments, but less compactness or smoothness of the resultant segments. Conversely, a very high shape parameter will result in segments that have very smooth, compact shapes, but more variance of spectral and topographic pixel values. For the FNF segmentation, a shape parameter of 0.1 was used, which emphasizes spectral and topographic homogeneity over smoothness and compactness of segment shapes.

Similar to the shape parameter, the compactness parameter actually weighs the balance between two opposing spatial qualities: compactness and smoothness. Compactness can be described as the ratio between the area of a given segment and the area of the smallest bounding box of that segment. A very compact segment (e.g., a circular or square segment) will have a ratio that approaches 1, while a segment with low compactness (e.g., an oblong or linear segment) will have a value that approaches 0. Smoothness can be described as the ratio between the length of a segment’s boundary and its area. A very smooth segment will have a short border relative to its area, whereas an irregular segment will have a lengthy border relative to its area. The value of the compactness parameter ranges from 0.0 (low compactness/high smoothness) to 1.0 (high compactness/low smoothness). For the FNF segmentation, a compactness parameter of 0.7 was used, which equally balances the shape and compactness of segments.

In addition to the base parameters described above, GTAC developed additional components to the segmentation rule set, including the definition of a minimum mapping feature (MMF) and associated MMF filtering techniques, and an “object smoothing” process that sends the raw segments through a majority filter-based re-shaping tool that results in smoother, more spatially consistent and functional modeling units.

Reference Data Collection

Vegetation plot data were assembled and aerial photo interpretation was conducted to obtain a reference data set representative of the map units (vegetation type, canopy cover, and tree size class) depicted on the final maps. Reference data are intended to represent a statistically robust sample of broader vegetation conditions across the entire study area. They are used both as training data in model development and to assist with image interpretation. For this project, three types of reference data were used: legacy vegetation plot data, newly collected field reference data, and photo-interpreted data.

Legacy Vegetation Plot Data

Existing information on vegetation composition and structure was reviewed for use in the mapping process. Each site that legacy plots were associated with was reviewed for segment homogeneity, if the site was relatively uniform in vegetation characteristics, and if the assigned vegetation group, vegetation type, and tree size class were appropriate. Multiple legacy data sources and associated plot information with and without accurate georeferencing were used for developing dominance type classifications (Table 1). A total of 383 legacy plots were used for developing dominance type classifications; 203 plots of the 383 plots had accurate georeferencing within the FNF boundary and underwent a rigorous QA/QC process using high resolution NAIP imagery; these plots can be used to intersect with the final maps to describe map units. The remaining 180 plots were either located outside of the FNF boundary, or the coordinates were associated to only the center of a Public Land Survey System section, which was not an accurate enough geospatial location to use for intersecting with the final maps for map unit descriptions.

Newly Collected Field Reference Data

Field reference data were collected to capture the variation of vegetation composition communities and structure classes across the project area. Field sites were selected using several criteria to ensure that representative vegetation conditions were sampled. First, an attempt was made to locate sites in relatively homogeneous areas as perceived from high resolution aerial imagery. Second, sites were large enough (one acre or greater) to capture variation in geospatial data to provide reasonable statistics for a particular sample. Third, sites were placed within 0.25 mile of a road or trail to facilitate accessibility in the field. In addition, spectral and topographic data and an existing landcover map were used to help capture the range of conditions anticipated to occur within the project area.

Approximately 1,120 field sites were visited on the Fishlake National Forest during the summers of 2014 and 2015. Sites consisted of segments representing vegetation patches or stands and non-vegetated areas. Information on dominance type, vegetation type, percent canopy cover, and tree size were collected at each site. Since the map represents an overhead view, all vegetation within the site area was assessed based on an aerial perspective from above the canopy. Overlapping canopy not visible from above was not assessed or included in the estimate.

For about 640 of the sites, three 50-foot radius circular descriptive or observation plots were established within the segment. For descriptive plots, ocular estimates of canopy cover for trees, shrubs, herbaceous, and non-vegetated cover types were recorded for the plot, totaling 100 percent. Based on these estimates, the vegetation formation for the plot was determined using the vegetation key and up to five most abundant species having greater than or equal to five percent cover recorded for that formation. Based on the plot composition and cover estimates, a dominance type and corresponding vegetation type and vegetation group were assigned to the plot using the vegetation keys and map unit cross-walk (Appendix C).

For forest and woodland plots, the percent visible cover from above of each tree size class was ocularly estimated by species and then totaled for each size class. Tree size for forest tree species was determined using DBH, while tree size for woodland tree species was calculated using DRC for its diameter value (Tables 2 and 3). The tree size class having the most abundant total canopy cover was used for assigning the forested plot to a tree size map unit.

For forest, woodland, and shrubland plots, total life form canopy cover was estimated to assign the plot to a tree or shrub canopy cover map unit. Upland forest and woodland plots were assigned to a tree canopy cover map unit, while shrub and riparian woody plots were assigned a shrub canopy cover map unit (Table 4). In addition to ocular cover estimates, a transect intercept method was used at regular intervals for shrub plots to calibrate ocular estimates.

In addition to descriptive plot information, two or three field observation plots were collected within the segment to quickly acquire additional composition and structure information within the extended vicinity of the field site, including dominance type, vegetation type and group, canopy cover class, and tree size class. Additional information regarding field sampling procedures is discussed in the Field Reference Data Collection Guide (Appendix D).

Photo Interpretation

In addition to the field-collected data, aerial photo interpretation was conducted for discernable vegetation composition and structure characteristics to validate and supplement the field-based reference data set. All legacy and newly acquired field reference data were photo-interpreted to validate segment homogeneity and representativeness of the field calls for vegetation type and structure class. In addition, supplemental photo interpretation reference sites were acquired for classes not adequately represented in the legacy or newly acquired field sample data sets.

Photo-interpretation techniques were used to assign canopy cover for about 433 randomly selected tree segments. Tree canopy cover was evaluated across the full extent of the modeling unit (segment) using high resolution imagery. Example segments, in which the canopy cover percent was established by multiple interpreters, were used to help calibrate individual interpretation. All sites were reviewed by two photo-interpreters to provide an impartial assessment. This process ensured more consistent tree canopy cover estimates, provided information for remote locations, and enabled the acquisition of an unbiased, random reference data set for modeling purposes.

Modeling

Modeling was the step in the mapping process that developed statistical relationships between reference data and geospatial data. These statistical relationships were then applied to building a map. To improve model results, reference data were reevaluated, changes or additions were made, and an updated model was developed. This modeling procedure was repeated until the maps were considered satisfactory.

An important task in the modeling process was the development of draft maps to share with FNF resource specialists. This step allowed resource specialists to take maps into the field for verification, apply local knowledge, and make suggestions for improvements to the map products. This feedback allowed modelers to make map changes and improvements prior to final map delivery.

Vegetation Type Map

Vegetation types were mapped using a hierarchical approach. A mapping hierarchy determined the sequence in which models were run, and incorporated the vegetation types most difficult to separate (Figure 5). Broad life form types, such as tree and non-tree, were mapped first.

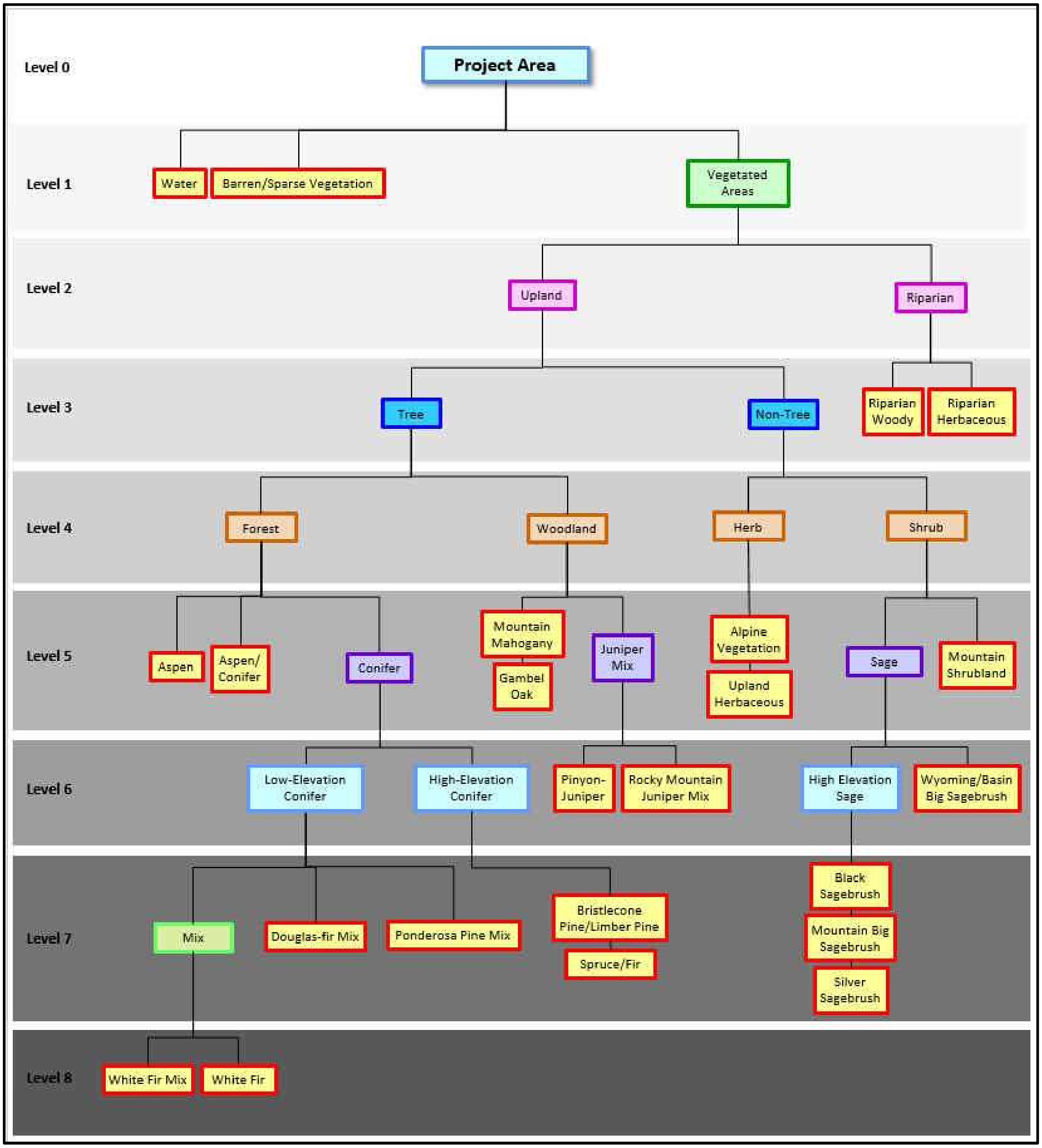


Figure 5: Vegetation type mapping hierarchy example used in the modeling process. Successive models were developed starting with level 1 (broad separation of land cover) and progressing to higher levels (more refined). At each level a separate map was developed and reviewed for accuracy. Yellow boxes depict vegetation type map units. Land use types (Agriculture and Developed) were not included in the hierarchy since they were manually delineated using high resolution imagery.

These communities were subsequently divided into more distinct categories until the final vegetation types were mapped. There are several advantages to using this hierarchical approach. It enables a targeted review of maps at each level where conspicuous errors can be addressed at the upper levels of the hierarchy, and it provides additional reference sites for mapping the broad classes.

The mapping hierarchy was developed using a data clustering technique based on the relative ability to separate each vegetation type. Ability to separate was determined by how well the spectral and ancillary data could distinguish between vegetation types. It is quantified by a value known as "entropy," which measures how well a model could be expected to separate vegetation types beyond random chance. Vegetation types with low entropy values are expected to be modeled poorly while vegetation types with high entropy values are expected to be modeled well.

A Random Forests model (Breiman 2001) was developed for each level of the mapping hierarchy, and the resulting output map was carefully evaluated. To correct inconsistencies, reference data were reevaluated, changes or additions were made, and an updated model was developed. This modeling procedure was repeated until the maps were considered satisfactory.

Canopy Cover Map

Canopy cover was assigned to forest, woodland, and shrubland modeling units identified on the vegetation type map. Forest and woodland canopy cover was determined using photo-interpretation techniques, while shrubland canopy cover was assessed in the field.

To optimize modeling effectiveness, vegetation types were sorted into tree and shrubland lifeform categories (Table 5), and for each lifeform a Random Forests model was developed. Tree canopy cover was modeled as a continuous variable, while shrubland types were modeled to a canopy cover class. These maps were evaluated using the high resolution imagery, and if necessary, additional reference sites were added.

Table 5: Canopy cover groups used for modeling canopy cover.

Canopy Cover Group	Vegetation Type
Tree	Aspen, Aspen/Conifer, Douglas-fir Mix, Ponderosa Pine Mix, White Fir, White Fir Mix, Spruce/Fir, Bristlecone Pine/Limber Pine, Mountain Mahogany, Pinyon-Juniper, Rocky Mountain Juniper Mix, and Gambel Oak
Shrubland	Mountain Big Sagebrush, Wyoming/Basin Big Sagebrush, Silver Sagebrush, Black Sagebrush, Mountain Shrubland, and Riparian Woody

Tree Size Map

Tree size was assigned to modeling units identified as forest or woodland vegetation types (Table 6). Diameter at breast height (DBH) was used for forest types while diameter at root collar (DRC) was taken for woodland types. Vegetation height information derived from IfSAR data was used in addition to the customary geospatial predictors (Appendix F).

Table 6: Tree groups and the associated vegetation types used for tree size mapping.

Tree Size Groups	Vegetation Type
Forest	Aspen, Aspen/Conifer, Douglas-fir Mix, Ponderosa Pine Mix, White Fir, White Fir Mix, Spruce/Fir, and Bristlecone Pine/Limber Pine
Woodland	Mountain Mahogany, Pinyon-Juniper, Rocky Mountain Juniper Mix, and Gambel Oak

Draft Map Review and Revision

The draft vegetation type, canopy cover, and tree size maps were provided to local Forest resource specialists for comment and review. Meetings were held where the review process and associated materials were presented to the Forest staff (Appendix G). Digital maps using Webmap services were the primary review device. This was an opportunity for local experts to assess the map and give additional information to make improvements. All draft map review comments were compiled and reviewed by the vegetation mapping team, and the recommended changes were used to produce the final maps.

Final Map Development

Three final map products were produced for delivery: 1) vegetation type, 2) canopy cover class for trees and shrubs, and 3) tree size class. For the vegetation type map, segments were first dissolved to merge adjacent polygons of the same type. To achieve the minimum map feature (MMF) of five acres, with the exception of riparian woody and riparian herbaceous (two acre MMF), segments below these thresholds were merged based on a set of rules developed by the RO and FNF staffs (Appendix H). These rules followed logic based on similarities between adjacent polygons, so that neighbors were merged with the most similar type of vegetation. An example of this dissolving and filtering process is shown in Figure 6. For canopy cover and tree size maps, segments were dissolved and merged using a similar process. For example, the first choice for filtering out a small TS1 map feature was to merge it with a neighboring TS2 map feature, since that is the most similar class.

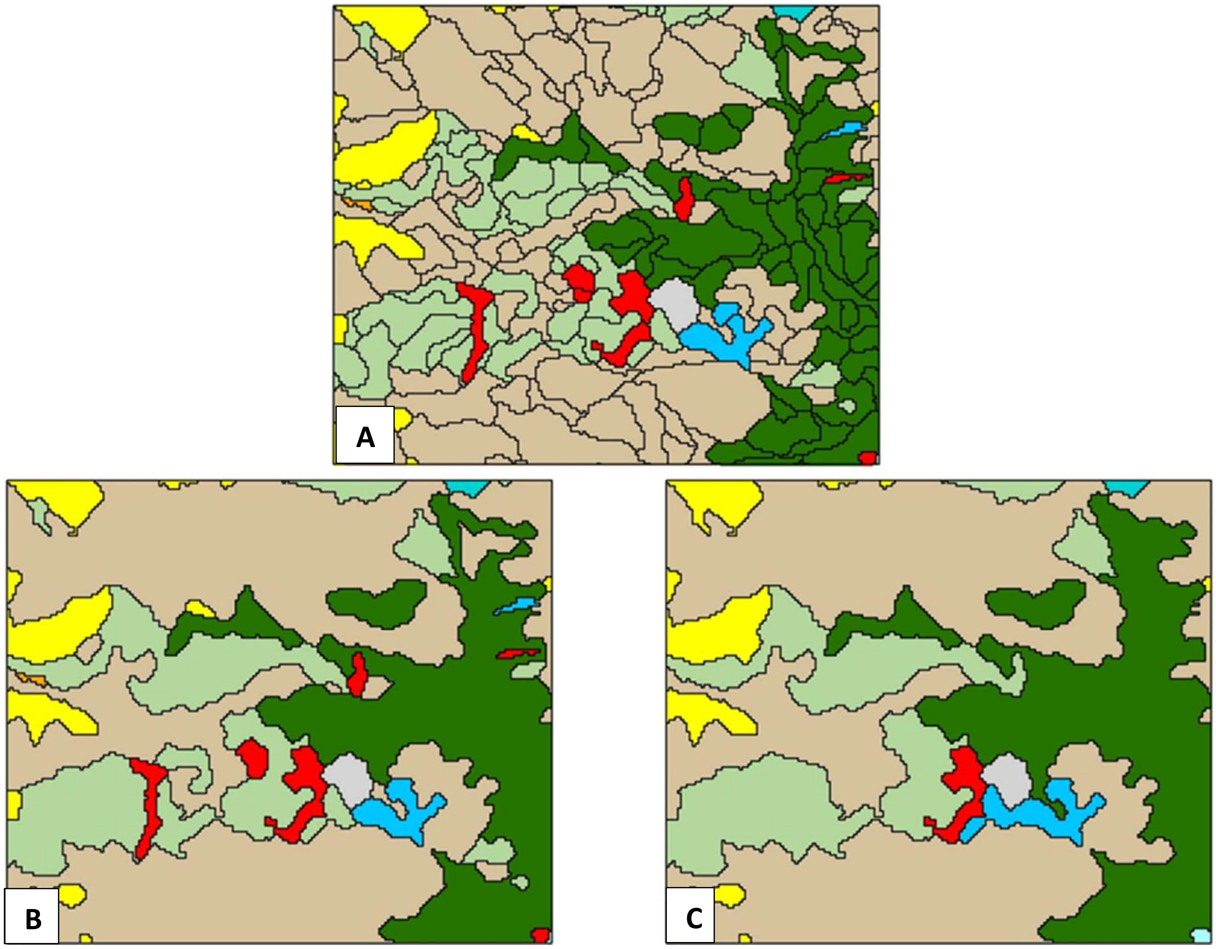


Figure 6: An example of the dissolving/merging and filtering process that was performed on the final maps. Image A shows the original vegetation type map with no dissolving or filtering. Image B illustrates the dissolving and merging of adjacent map features labeled with the same vegetation type. Image C illustrates the filtering process. Segments smaller than the designated minimum map feature size were merged with similar adjacent map features based on the filtering rule-set.

Map Products

The final map products provide for continuous land cover, vegetation type, tree size, and canopy cover information for the entire Fishlake National Forest. The final maps were formatted as a digital geodatabase, which is compatible with Forest Service corporate GIS software. Categories included vegetation group and vegetation type, canopy cover class, and tree size class. The vegetation map is consistent with mid-level mapping standards set forth in the Existing Vegetation Classification, Mapping, and Inventory Technical Guide (Nelson et al. 2015). These minimum map feature standards were also maintained in the canopy cover and tree size class maps.

All mapped areas in the subsequent tables are based upon acreage values calculated in the Region 4 Albers Equal Area projection and the version of Automated Lands Project (ALP) Forest Service ownership that is currently archived in the project record. For area comparison purposes, the use of Region 4 Albers Equal Area projection was preferred over a UTM projection due to its more accurate representation of acreage values across the entire geographic area of Region 4. Changes in the ALP data set or using area calculations from other spatial references will result in variations of total acreages. Total values for many of these tables may not add up correctly due to rounding of their corresponding input values.

Vegetation Type and Group

A total of 25 vegetation types comprising eight generalized groups were mapped (Table 7). These classes ranged from specific vegetation species (e.g., Gambel Oak) to vegetation communities (e.g., Mountain Shrubland) and more general land use types (e.g., Developed).

Table 7: Total acres and percent area of vegetation types by vegetation groups. Only National Forest System lands were included in the acreage calculations.

Vegetation Type	Area (ac)	% Area
Alpine		
Alpine Vegetation	1,921	0.1
Conifer Forest		
Spruce/Fir	96,503	6.6
White Fir Mix	38,991	2.7
Douglas-fir Mix	26,955	1.9
White Fir	20,260	1.4
Ponderosa Pine Mix	12,918	0.9
Bristlecone Pine/Limber Pine	2,656	0.2
Deciduous Forest		
Aspen/Conifer	112,504	7.7
Aspen	95,981	6.6
Herbland		
Upland Herbaceous	77,429	5.3
Non-Vegetated/Sparse Vegetation		
Barren/Sparse Vegetation	35,300	2.4
Water	1,939	0.1
Developed	524	0.0
Agriculture	15	0.0
Riparian		
Riparian Woody	9,850	0.7
Riparian Herbaceous	2,486	0.2
Shrubland		
Mountain Big Sagebrush	98,294	6.8
Wyoming/Basin Big Sagebrush	53,225	3.7
Black Sagebrush	33,951	2.3
Mountain Shrubland	31,835	2.2
Silver Sagebrush	20,248	1.4
Woodland		
Pinyon-Juniper	365,928	25.2
Gambel Oak	259,027	17.8
Mountain Mahogany	47,959	3.3
Rocky Mountain Juniper Mix	6,219	0.4
Total	**1,452,917**	**100.0**

Tree and Shrub Canopy Cover

A canopy cover map was generated by independently processing tree and shrubland canopy cover (Table 8). All other areas were mapped as having no canopy cover. Canopy cover categories were assembled into a wall-to-wall map for the entire Fishlake National Forest.

Table 8: Total map acres and percent area for each tree and shrubland canopy cover class. Only National Forest System lands were included in the acreage calculations.

Tree Canopy Cover Class	Area (ac)	% Area
TC1 (10 - 19%)	170,287	15.7
TC2 (20 - 39%)	526,035	48.4
TC3 (40 - 49%)	182,182	16.8
TC4 (50 - 59%)	120,982	11.1
TC5 (≥ 60%)	86,412	8.0
Total	**1,085,900**	**100.0**

Shrub Canopy Cover Class	Area (ac)	% Area
SC1 (10 - 24%)	117,979	47.7
SC2 (25 - 34%)	46,689	18.9
SC3 (≥ 35%)	82,735	33.4
Total	**247,403**	**100.0**

Tree Size

A tree size map was generated for all areas identified as forest or woodland in the existing vegetation map. These lands were classified into one of five forest (timber) size classes or four woodland size classes (Table 9). All other areas were mapped as having no size class. The tree size class map was assembled into a complete coverage for each mapping region and mosaicked for the entire Fishlake National Forest.

Table 9: Total map acres and percent area for each tree size class. Only National Forest System lands were included in the acreage calculations.

Tree Size DBH or DRC Class (in)	Area (ac)	% Area
FS1 (0 - 4.9" DBH)	9,955	0.7
FS2 (5 - 11.9" DBH)	331,967	22.8
FS3 (12 - 17.9" DBH)	64,457	4.4
FS4 (18 - 23.9" DBH)	92	0.0
FS5 (≥ 24 DBH)	297	0.0
WS1 (0 - 5.9" DRC)	241,635	16.6
WS2 (6 - 11.9" DRC)	422,647	29.1
WS3 (12 - 17.9" DRC)	7,123	0.5
WS4 (≥18" DRC)	7,729	0.5
NT (Non Tree)	367,017	25.3
Total	**1,452,917**	**100.0**

Accuracy Assessment

An accuracy assessment for a mapped product can be defined as a statistical summary or metric, usually presented as a table, comparing the mapped classes to reference data or "truth". An accuracy assessment should provide objective information on the quality or reliability of the map, and can be used to determine the utility of the map and its associated risks with respect to specific applications (Nelson et al. 2015). Thus, it is important that the reference information used to conduct accuracy assessments be independent from the information used to produce the map and also be a reliable and unbiased source for representation of ground conditions.

Quantitative inventory data were used for the accuracy assessment on the FNF. This included the most current FIA, base-level, field-collected data available for each plot; consisting of a spatially complete systematic grid sample for all forest and nonforest lands. This source data spanned a full cycle of ten years (2005-2015) of FIA annual inventory plots on the FNF. Systematic inventory plots provide a spatially balanced estimate of map unit (e.g., vegetation type, canopy cover class, and tree size class) proportions for a population. Below are more detailed discussions concerning: 1) the use of reference datasets for accuracy assessments, 2) the use of the map product from an accuracy assessment perspective, and 3) the accuracy assessment design.

Use of Reference Data Sets for Accuracy Assessments

Reference data is quantitative or qualitative information about ground features necessary to successfully complete a map accuracy assessment. Although the collection of field reference data is not required, some type of reference data is needed to help interpret and/or assess accuracy during a mapping project. Quantitative accuracy assessments usually depend on the collection of reference data, which is assumed to be known information of high accuracy (Brewer et al. 2005).

There is rarely a sufficient sample size to quantify all vegetation types occurring across a geographic area. Important types of naturally small extent, such as riparian communities, are rarely sampled by a systematic or random design. Inventory data, therefore, involves trade-offs between resolution and reliability. It is often necessary to generalize or aggregate vegetation types and/or structural classes in order to achieve the sample sizes needed to provide statistically reliable estimates of the amounts of those types or classes (Brewer et al. 2005).

When data collection protocols for accuracy assessment samples are similar to those of the training samples, then assigning the appropriate map unit label to an accuracy assessment sample is straightforward. If plot designs are dissimilar, then developing a crosswalk and reinterpreting or verifying plot information using high-resolution imagery, or conducting field visits may be necessary. When existing data, such as FIA data, is used to assess map accuracy, consideration should be given to address differences in data collection methods (Stehman and Czaplewski 1998). The following are some limitations that need to be considered when using FIA or other data not explicitly designed for accuracy assessments:

- Size of FIA plot vs. unit of evaluation for the map,
- Nature of FIA condition boundaries vs. mapped polygon boundaries,
- Vintage of field collected data of annual cycle vs. vintage of imagery, and
- Insufficient numbers of accuracy assessment sites for less common classes.

One consideration when using FIA data is that it is typically collected on a ten year cycle by the Interior West FIA (IWFIA) unit, such that one-tenth of each state is sampled each year. As a result, the average measurement period for a ten year cycle of plot data would be about five years. An analyst must determine how well the remotely-sensed data used for modeling, which may have been taken during one or more years, will coincide temporally with ten years' worth of measurement dates for plot data. Such differences may cause additional accuracy errors if there were significant disturbances in vegetation types or cover during that time.

Although the use of FIA data as a reference data set for accuracy assessments has its limitations, it also has many advantages. FIA data are a statistically robust, spatially distributed, unbiased sample that is updated annually over a ten year cycle. It has well-established and consistent data collection protocols that facilitate multi-temporal comparability and long-term usage. FIA data are also readily available to users.

FIA data can be used early in the classification scoping process to identify or distinguish rare (less than one percent of area on a Forest), uncommon (one to ten percent), and common (greater than ten percent) classes. Rare classes are typically too spatially limited for normal mid-level mapping processes, and may need to be incorporated ("burned in") later using local knowledge from Forest Service employees. This process can help make the mapping process more efficient by reducing the number of initial classes and/or the number of classes that may need further collapsing following an accuracy assessment based on too few samples. Other sources of reference information are often needed (e.g., intensified, stratified, or photo-interpreted data) for less common classes.

Use of Map Products

Map features (e.g., polygons) rarely have homogeneous characteristics; instead, they usually contain varying proportions of vegetation, structure, and cover class mixtures. Therefore, map products should be used within the context of the map unit and the associated dominance type descriptions.

The map assessment may identify map units with low accuracy. These map units may meet the desired thematic detail but not the desired thematic accuracy. By assessing the error structure relative to the mapping objectives and management questions, map units can be combined into new, more generalized map units that better meet accuracy requirements. Merging map units is not an edit or a correction to the final map; rather, this process is a generalization of the map legend to achieve an acceptable compromise between thematic detail and classification accuracy (Nelson et al. 2015).

Accuracy Assessment Design

The three basic components of an accuracy assessment are: sample design, response design, and the analysis protocol (Stehman and Czaplewski 1998). The sample design determines the plot design and the distribution of sites across the landscape. The response design determines how the sites are labeled or assigned to map units. The analysis protocol summarizes the results of information obtained from the sampling and response designs.

Sample design and sample size (number of samples) are important considerations for an efficient accuracy assessment. The *sample design* should be statistically and scientifically valid. The sampling unit (i.e., polygon or point) should be identified early in the process since it affects much of the plot design. While training data used for producing a map may be collected according to a preferential or representative sampling scheme (purposive sampling), data used for an accuracy assessment should be collected using an unbiased approach where samples have a known probability of selection (Stehman and Czaplewski 1998). The number of sample sites should be large enough to be statistically sound but not larger than necessary for the sake of efficiency. The need for statistical validity is often balanced with practical considerations, such as time and budget constraints (Nelson et al. 2015).

The *response design* includes procedures for collecting the accuracy assessment samples and protocols for assigning a map unit label to each accuracy assessment sample (Stehman and Czaplewski 1998). If an existing data set is used, then the information needs to be deemed sufficient for assigning a map unit label. Additional information or interpretations may be needed as well.

The *analysis protocol* summarizes the results of information obtained from the sampling and response designs (Stehman and Czaplewski 1998). A primary objective of an accuracy assessment is to quantify the level of agreement between mapped and observed attributes. This is most often performed for classified (categorical) maps by creating an error matrix, and deriving accuracies from that matrix. The error matrix is the standard way of presenting results of an accuracy assessment (Story and Congalton 1986). This matrix is a cross-tabulation table that shows the number of reference sites found in every combination of reference data category and map unit category. Agreement can also be measured by comparing the similarity of the mapped and observed proportions of the attributes within the mapped area.

Quantitative Inventory

Quantitative vegetation inventory consists of applying an objective set of sampling methods to quantify the amount, composition, condition, and/or productivity of vegetation within specified limits of statistical precision. To be most useful, a quantitative inventory must have a statistically valid sample design, use unbiased sampling methods, and provide both population and reliability estimates (Brewer et al. 2005).

Phase 2 FIA Base-level Inventory

The FIA program of the USDA Forest Service has been in continuous operation since 1930. Their mission is to conduct and continuously update a comprehensive inventory and analysis of the present and prospective conditions of the renewable resources of the forests and rangelands of the United States. This national program consists of four regional FIA units. The IWFIA unit, part of the Rocky Mountain Research Station, conducts inventories throughout National Forest System Regions 1, 2, 3, and 4.

Forest Lands

Although FIA's mission includes rangeland assessments, it was only funded to conduct forest land inventories. The Phase 2 forest inventory consists of permanently establishing field sampled plots distributed across each state with a sample intensity of about one plot per 6,000 acres. Field data are typically collected only on plot locations where forest land is present. In general, forest land has at least ten percent canopy cover of live tally tree species of any size or has had at least ten percent canopy cover of live tally species in the past; based on the presence of stumps, snags, or other evidence. Each plot consists of a cluster of four subplots that fall within a 144-foot radius circle based on the plot center spread out over approximately 1.5 acres. Most Phase 2 data are related to tree and understory vegetation components of the forest. Plots are distributed across all ownerships throughout the United States; therefore, there are a number of plots in proportion to the extent of a vegetation type on the landscape. For more details on the national FIA program visit http://www.fia.fs.fed.us/ or for the IWFIA program at http://www.fs.fed.us/rm/ogden/.

All Condition Inventory

The USFS Intermountain Region (Region 4) has entered into an agreement with IWFIA to conduct an "All Condition Inventory" (ACI) on Region 4 National Forest System (NFS) lands, which is a base-level, quantitative inventory that collects similar vegetation information on both forest and nonforest conditions throughout the Intermountain Region. ACI was initiated as a joint effort by FIA and the USFS Northern Region (Region 1), in which the protocol was adapted and expanded to meet Region 4 needs. As an extension of the grid-based forest land inventories that IWFIA conducts on all ownerships throughout the Interior West states, ACI will result in a consistent and unbiased wall-to-wall inventory on all Region 4 NFS forest and nonforest lands. A nonforest condition includes all lands not considered a forest condition by FIA's definition of forested lands. Thus, the Northern and Intermountain Regions have collaborated with IWFIA to conduct a seamless inventory with the same data collection protocols on all NFS lands regardless of the presence or absence of tree cover.

Methods

In general, quantitative inventory data from FIA plots can be used for many assessments or as complementary information for other projects. Mid-level vegetation mapping typically produces three layers of information: dominance type, canopy cover, and tree size. Since the inventory data are a true sample (systematic and random) of these characteristics across the landscape (e.g., a national forest, county, or state), the data can be used in ways that complement the mapping process, as an independent data set to assess the accuracy of the maps, or both. For mid-level mapping purposes, there are several ways in which the inventory data can be used:

- Understanding the proportional distributions of forest dominance types, tree sizes, and canopy cover across a map project area for map unit design and intermediate map evaluation purposes,
- Designed-based (e.g., FIA plots) vs. model-based area estimate comparisons of the final map products (non-site-specific), and
- Site-specific accuracy assessment.

The methods used for data preparation and classification, non-site-specific area estimate comparison, and site-specific accuracy assessment are discussed below for this project using FIA base-level plot data. The set of FIA base-level plots used for this accuracy assessment are referred to in the subsequent accuracy assessment subsections of this report as “inventory” plots.

Data Preparation and Classification

The first step in the data preparation process was acquiring data. Before classification began, it was necessary to query data from IWFIA’s regional database, join the proper tables, and calculate variables used in this process. Quality control checks were run on previously populated and vetted statewide national databases to assure that plot-level and condition-level estimates (e.g., live basal area per acre estimates, understory vegetation species, and lifeform cover estimates) were correct.

The next step was assigning dominance types to the plot/condition-level data (some plots have multiple conditions) in conjunction with the classification criteria outlined in the FNF Existing Vegetation Keys (Appendix C). This complicated step involved separating plots and their plot conditions into many categories in order to use the appropriate available information for a particular condition’s characteristics. The FIA plot layout and an example scenario where more than one condition exists on a plot are illustrated in Appendix I.

Species-level canopy cover data were available for all lifeforms except trees. A variable that provides “total live crown cover for all tree species” was collected on all plots to determine necessary thresholds for forest and woodland dominance types. Basal area (BA) by species was used to calculate total crown cover by tree species, which was then used in the classification key.

The following lists summarize the primary steps involved in assigning vegetation dominance types, tree size, and crown cover.

Vegetation dominance type steps included:

- Calculate live BA per acre estimates by species,
- Convert to percentages of total live BA by species,
- Identify species with plurality of percent live BA ,
- Use live BA percentages as a surrogate in the classification key for identifying species that are the most abundant in terms of relative cover,
- Where necessary in classification key, use total cover to convert to absolute cover,
- Determine general plot vegetation characteristics based upon vegetation groups and allocate into classes,
- Assign the appropriate dominance type, vegetation type, and vegetation group according to the classification key, and
- Determine if plot data are relevant due to potential disturbance since plot measurement. If they are not relevant, determine another method of assigning dominance type information (imagery, plot photos, notes, etc.) so plot information is current with map information.

Tree Size steps included:

- Calculate live BA per acre estimates by diameter class,
- Convert to percentages of total live BA by diameter class and species,
- Identify diameter class with plurality of percent live BA,
- Assign diameter classes to plot/conditions, and
- Determine if plot data are relevant due to potential disturbance since plot measurement. If they are not relevant, determine another method of assigning tree size information (imagery, plot photos, notes, etc.) so plot information is current with map information.

Canopy cover steps included:

- Use total live tree cover (greater than 10 percent) attribute to determine forest and woodland conditions,
- If total live tree cover is less than 10 percent, then use understory vegetation cover estimates by lifeform and species to determine nonforest cover classes, and

- Determine if plot data are relevant due to potential disturbance since plot measurement. If they are not relevant, determine another method of assigning crown or shrub cover information (imagery, plot photos, notes, etc.) so plot information is current with map information.

Non-Site-Specific Accuracy Assessment

A non-spatial comparison of design-based (inventory) vs. model-based (mapped) area outputs is one approach of assessing a map product. Such a comparison was, in-part, the reason that the Forest Service management decision appeal was affirmed in the Mission Brush Case (Lands Council vs. McNair 2008). Designed-based estimates such as those obtained by using FIA plot data provide an excellent source of accuracy assessment information since it is a true systematic random sample.

Stratification for Area Estimates

Area expansion factors were generated for each inventory plot/condition, which signifies the area that an inventory plot represents at the population level. The stratification process is an important step in determining area estimates from inventory data as it provides an area representation from which area expansions can be determined. A stratification crosswalk was used for the FNF to classify plots into generalized categories based upon their map-assigned strata (Table 10). Vegetation groups were classed into one of eight strata, based upon their vegetation characteristics. Some vegetation groups with relatively large acreages were given their own strata layer, which typically assists in the inventory estimation process.

These data were considered a legitimate, unbiased sample because the inventory plots were spatially distributed, unbiased estimates, and all data collection protocols were consistent (between forest or nonforest conditions). There were a total of 288 plot/conditions used for the area estimation from a total of 243 inventory plot locations (non-sampled plot/conditions were not considered in the area estimation process). As part of the plot data collection protocol, conditions are mapped and sampled separately for each plot since they are considered an area of relatively uniform ground cover (i.e., homogeneous vegetation cover), which allows area weights to be assigned using condition proportions. Based upon the area of the strata and the distribution of plots, an area expansion factor was applied to each plot/condition based upon its strata value.

Table 10: Inventory plots were grouped into generalized map strata using their vegetation map unit and the following crosswalk. These general strata classifications help inform the inventory estimation process by assigning plots to strata. Six map units (Alpine Vegetation, Riparian Herbaceous, Riparian Woody, Agriculture, Developed, and Bristlecone Pine/Limber Pine) were omitted from this table since they had zero acres (i.e., no FIA plot intersected these map units).

Strata	Vegetation Map Unit	Acres
Pinyon-Juniper_mix	Pinyon-Juniper	359,145
	Rocky Mountain Juniper Mix	13,002
Woodland_mix	Gambel Oak	247,482
	Mountain Mahogany	59,504
Shrubland	Mountain Big Sagebrush	106,273
	Black Sagebrush	43,760
	Wyoming/Basin Big Sagebrush	43,760
	Silver Sagebrush	25,006
	Mountain Shrubland	18,754
Deciduous_Forest	Aspen	111,277
	Aspen/Conifer	97,208
Conifer_mix	White Fir Mix	61,685
	White Fir	24,674
	Douglas-fir Mix	12,337
	Ponderosa Pine Mix	3,084
Spruce/Fir	Spruce/Fir	96,503
Herbland_Alpine_Riparian_mix	Upland Herbaceous	91,686
Non_Vegetated/Sparse_Vegetation	Barren/Sparse Vegetation	28,334
	Water	9,445
Total		**1,452,917**

Site-Specific Accuracy Assessment

Another use for a quantitative inventory (e.g., FIA plots) is for conducting site-specific accuracy assessments on existing vegetation mid-level map products. The use of all plots was necessary so that the systematic, unbiased nature of the grid was not compromised. This assessment was completed by comparing the center subplot centroid location of an FIA plot (Appendix I) to the spatially coincident location of a mapped polygon feature.

It was determined that to best portray map accuracy, the assessment would be performed on the final map features, and not the intermediate modeled segments, which serve as the building blocks for the final map product. This resulted in polygons that were at least the same size but more often larger than assessment segments, which allowed a larger percentage of plots to fit entirely within an evaluation unit, which reduced the number of plots that potentially straddled segments. Consequently, some polygons were relatively large. Due to the inherent differences between the inventory sample design and map characteristics, the inventory sample design (e.g., size of plot), the field data collection protocols, and the defining attributes (forest type, tree size, tree cover density, etc.) associated with inventory vegetation condition boundaries were often not in complete alignment with the size or characteristics of the mid-level mapped polygon boundaries.

As noted in the "Data Preparation and Classification" section, FIA plot data were evaluated to determine if they were still relevant due to potential disturbances (primarily stand-altering wildfires) since plot measurement occurred, or before plot measurement occurred for fire disturbances after 2011, which was the earliest primary remotely-sensed imagery date used for producing the map (Appendix A). After obtaining fire history data, it was determined that 52 FIA plot/conditions were within the burn perimeters of major wildfires for the FNF. From those 52 plot/conditions, additional inspection was performed to compare fire disturbance year against both plot measurement year and imagery date (i.e., plots that were significantly disturbed by fire between the timeframe of plot measurement and imagery date were analyzed further). It was determined that only one plot/condition was altered enough by fire disturbance to categorize it as "disturbed". Consequently, the corresponding data (vegetation types, tree sizes, cover estimates, etc.) for that one plot/condition was updated with additional, more relevant data (imagery, plot photos, field crew notes, etc.) so that plot information would be current with map information (i.e., both remotely-sensed data and plot data were again in sync regarding a disturbance).

Prior accuracy assessments used an involved process of analyzing inventory plots against map polygons by applying decision rules regarding the use of plots based upon their location within a polygon and/or near a polygon edge. For the FNF assessment, it was decided to objectively use the subplot center location without any adjustments. This process allows for a more objective and repeatable accuracy assessment.

Results

Non-Site-Specific Accuracy Assessment

Classification and stratification of inventory plot/conditions for generating area estimates was performed, resulting in area estimates for vegetation group, vegetation type, tree size class (forest and woodland), and canopy cover class (tree and shrub). Total values of area estimates for many of these tables may not add up correctly due to rounding of their corresponding input values.

Area Estimates Based on Inventory Plots

The source data set for this analysis was obtained from approximately ten years (2005-2015) of FIA data; including All Condition Inventory (ACI) data, which were gathered to gain a representation of nonforest plots. There were a total of 288 plot/conditions available for area estimation from a total of 243 inventory plot locations. When plots have more than one vegetation condition, condition-level plot data was used for area estimates. While the area classification focused on condition level data, the site-specific accuracy assessment focused on plot level information and its spatial relationship to the mapped polygons.

Summarized inventory data results for predicted area, percent area, and number of plot/conditions by five map attributes (vegetation group, vegetation type, tree size class, tree canopy cover class, and shrub canopy cover class) are presented in the following sections.

Vegetation Group Area Estimates

Area estimates for eight vegetation group categories on the FNF are presented in Table 11. Approximately 74 percent of the FNF is in forest and woodland groups, while about 26 percent are in nonforest groups. The Woodland group is the largest with 47 percent total area, followed by the Deciduous Forest group at almost 15 percent, then the Conifer Forest group at nearly 12 percent total area. The Shrubland group is 11 percent, while the remaining groups are each less than nine percent of the area. The FNF had relatively few inventory plot/conditions representing riparian (two) or alpine (one) vegetation groups.

Table 11: Inventory-estimated area (acres), percentage of total area, and number of FIA plot/conditions listed by both forest/nonforest and vegetation group categories for the FNF.

Vegetation Group	Area (ac)	% Total Area	Number of Plot/Conditions
Forest and Woodland			
Woodland	691,195	47.6	125
Deciduous Forest	212,235	14.6	47
Conifer Forest	170,553	11.7	33
Forest and Woodland Total	**1,073,983**	**73.9**	**205**
Nonforest			
Shrubland	161,048	11.1	34
Herbland	129,848	8.9	28
Non-Vegetated/Sparse Vegetation	76,848	5.3	18
Riparian	6,364	0.4	2
Alpine	4,826	0.3	1
Nonforest Total	**378,933**	**26.1**	**83**
Total	**1,452,917**	**100.0**	**288**

Vegetation Type Area Estimates

Area estimates for 22 vegetation type categories on the FNF are presented in Table 12. Pinyon-Juniper vegetation type covered the largest area with 27 percent (by acres), followed by Gambel Oak (11 percent), Upland Herbaceous (almost nine percent), Aspen (eight percent), Mountain Mahogany (seven percent), and Aspen/Conifer (six percent). The remaining vegetation types each composed less than six percent of the total area. Thirteen vegetation types also had less than ten classified inventory samples each, which reflects the relative scarcity of occurrence of those types across the FNF. Vegetation types without inventory samples (Agriculture, Riparian Herbaceous, and Ponderosa Pine Mix) were not included in this table.

Table 12: Inventory-estimated area (acres), percentage of total area, and number of plot/conditions by both forest/nonforest and vegetation type categories for the FNF. Vegetation types without inventory samples (Agriculture, Riparian Herbaceous, and Ponderosa Pine Mix) were not listed to simplify the table.

Vegetation Type	Area (ac)	% Total Area	Number of Plot/Conditions
Forest and Woodland			
Pinyon-Juniper	395,650	27.2	65
Gambel Oak	163,299	11.2	37
Aspen	125,438	8.6	28
Mountain Mahogany	108,165	7.4	18
Aspen/Conifer	86,798	6.0	19
Spruce/Fir	75,908	5.2	16
White Fir	41,167	2.8	7
White Fir Mix	30,865	2.1	5
Rocky Mountain Juniper Mix	24,082	1.7	5
Douglas-fir Mix	11,983	0.8	3
Bristlecone Pine/Limber Pine	10,631	0.7	2
Forest and Woodland Total	**1,073,983**	**73.9**	**205**
Nonforest			
Upland Herbaceous	129,848	8.9	28
Mountain Big Sagebrush	78,343	5.4	16
Barren/Sparse Vegetation	64,148	4.4	14
Black Sagebrush	28,194	1.9	6
Mountain Shrubland	26,637	1.8	7
Wyoming/Basin Big Sagebrush	16,486	1.1	3
Silver Sagebrush	11,388	0.8	2
Water	9,485	0.7	2
Riparian Woody	6,364	0.4	2
Alpine Vegetation	4,826	0.3	1
Developed	3,215	0.2	2
Nonforest Total	**378,933**	**26.1**	**83**
Total	**1,452,917**	**100.0**	**288**

Tree Size Class Area Estimates

Area estimates for 10 tree size classes on the FNF are presented in Table 13. Tree size class area was estimated for forest species (FS1-FS5), woodland species (WS1-WS4), and non tree (NT) categories. Non Tree was the most common class (NT, 26 percent), followed by Forest Size Class 2 (FS2, almost 20 percent), which represents the 5 - 11.9” DBH diameter class. The most common woodland class was Woodland Size Class 4 (WS4, ≥ 18" DRC), which covers 14 percent of the FNF. Tree size classes less than 12” diameter (FS1, FS2, WS1, and WS2) spanned about 48 percent of the total area, while those classes with 18” or larger diameters (FS4, FS5, and WS4) accounted for 16 percent.

Table 13: Inventory-estimated area (acres), percentage of total area, and number of plot/conditions by tree size classes for forest species (FS1-FS5), woodland species (WS1-WS4), and Non Tree (NT) for the FNF.

Tree Size Code	Tree Size Class DBH or DRC (in)	Area (ac)	% Total Area	Number of Plot/Conditions
Forest				
FS1	0 - 4.9" DBH	23,023	1.6	6
FS2	5 - 11.9" DBH	289,641	19.9	56
FS3	12 - 17.9" DBH	41,013	2.8	10
FS4	18 - 23.9" DBH	20,946	1.4	6
FS5	≥ 24" DBH	8,167	0.6	2
Woodland				
WS1	0 - 5.9" DRC	178,880	12.3	40
WS2	6 - 11.9" DRC	202,713	14.0	33
WS3	12 - 17.9" DRC	100,708	6.9	17
WS4	≥ 18" DRC	208,893	14.4	35
Non Tree				
NT	Non Tree	378,933	26.1	83
Total		**1,452,917**	**100.0**	**288**

Canopy Cover Class Area Estimates

Area estimates for nine canopy cover classes on the FNF are presented in Table 14. Canopy cover area was estimated for both tree and shrubland canopies. The tree cover classes (TC) were primarily dominated by Pinyon-Juniper, Gambel Oak, Aspen, Mountain Mahogany, Aspen/Conifer, and Spruce/Fir vegetation types, while the shrubland cover classes (SC) were mostly comprised of Mountain Big Sagebrush (Table 12). The most prevalent cover class was TC2 at nearly 23 percent total area, followed by TC5 with 21 percent. The Non Tree/Non Shrub class accounts for over 14 percent of the FNF, with TC3 about 14 percent, and the remaining cover classes each below nine percent. Tree cover classes make up nearly 74 percent of the total area, while shrubland cover classes comprise about 12 percent. The primary reason for the large representation of areas in the tree cover classes is the prevalence of Pinyon-Juniper and Gambel Oak vegetation types across the FNF.

Table 14: Inventory-estimated area (acres), percentage of total area, and number of plot/conditions by tree and shrub canopy cover classes for the FNF.

Canopy Cover Code	Canopy Cover Class	Area (ac)	% Total Area	Number of Plot/Conditions
Tree				
TC1	10 - 19%	103,412	7.1	18
TC2	20 - 39%	332,354	22.9	61
TC3	40 - 49%	201,498	13.9	37
TC4	50 - 59%	121,519	8.4	23
TC5	≥ 60%	315,201	21.7	66
Shrub				
SC1	10 - 24%	92,795	6.4	18
SC2	25 - 34%	54,437	3.7	15
SC3	≥ 35%	25,006	1.7	4
Non Tree/Non Shrub				
NT/NS	Non Tree/Non Shrub	206,696	14.2	46
Total		**1,452,917**	**100.0**	**288**

Comparisons of Mapped to Inventory Area Estimates

In general, map units with many categories such as vegetation type tend to have more discrepancies between the mapped area estimates and field sampled occurrences. This is probably due to more and finer thresholds hindering recognition of class spectral signatures, and may also be due in part to limitations in the number of accuracy assessment sites available from quantitative inventory plots.

Vegetation Group Comparisons

An examination was performed to compare inventory-derived estimates and mapped area acreages for the eight vegetation groups of the FNF (Table 15, Figure 7). The Woodland vegetation group composes more than 46 percent of map area and over 47 percent of inventory area. The Shrubland group spanned over 16 percent of map area and 11 percent of inventory area. Agreements between the map and inventory area estimates for most vegetation groups were relatively close (Figure 7). The largest discrepancy between inventory and mapped area was exhibited in the Shrubland vegetation class (five percent difference), followed by the Herbland class (over three percent difference). The remaining vegetation groups were each less than three percent difference in area estimates for the FNF. Discussions regarding inventory confidence interval estimates and an error matrix component of this report will further evaluate these acreage differences.

Table 15: Mapped versus inventory-based estimates of area by existing vegetation groups for the FNF. Acreage and Percent Differences are based on the difference of total area between mapped and inventory estimates. A positive difference indicates estimated mapped acres exceed inventory acres for that class, while a negative difference implies more inventory acres than estimated mapped acres.

Veg Group Code	Vegetation Group Class	Map Acres	Map % of Total Area	Inventory Acres	Inventory % of Total Area	Acreage Difference	% Difference
W	Woodland	679,132	46.7	691,195	47.6	-12,063	-0.9
S	Shrubland	237,552	16.4	161,048	11.1	76,504	5.3
D	Deciduous Forest	208,485	14.3	212,235	14.6	-3,750	-0.3
C	Conifer Forest	198,283	13.6	170,553	11.7	27,730	1.9
H	Herbland	77,429	5.3	129,848	8.9	-52,419	-3.6
N	Non-Vegetated/Sparse Vegetation	37,778	2.6	76,848	5.3	-39,070	-2.7
R	Riparian	12,336	0.8	6,364	0.4	5,972	0.4
A	Alpine	1,921	0.1	4,826	0.3	-2,905	-0.2
Total		**1,452,917**	**100.0**	**1,452,917**	**100.0**	**n/a**	**n/a**

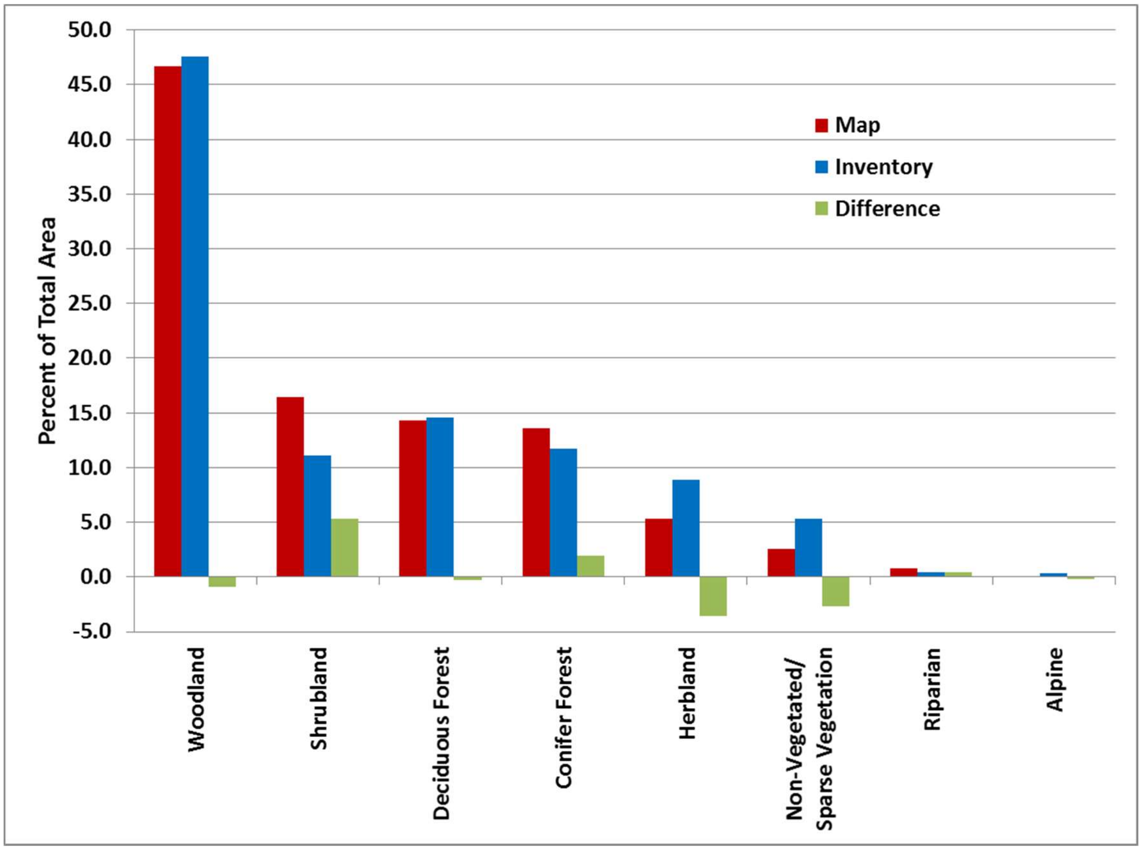


Figure 7: Comparison of mapped and inventory-based estimates of area as a percentage of total area, by vegetation group on the FNF. A positive difference indicates mapped acres exceed inventory acres for that group, while a negative difference shows that inventory acres exceed mapped acres.

Confidence Interval (95 Percent Standard Error) for Vegetation Groups

Using the Forest Inventory Estimation for Analysis tool (FIESTA) (Frescino et al. 2012), it is possible to generate 95 percent standard error values around area estimates of sampled inventory data. By definition, these standard error values represent a 95 percent statistical likelihood that the true value of the estimate ranges within the bounds of the confidence intervals. However, standard error values are highly influenced by sample size. In some cases, map classes are not represented well within the inventory data, which may result in relatively large confidence intervals. The FIESTA-based estimates are more appropriate for classes with high sampled area representations. The bounding values give a better idea of where the area estimates should fall, which also informs the accuracy assessment of the maps.

Area estimates from the map product for five of the eight vegetation groups were within their corresponding 95 percent confidence interval values based on their inventory-based estimates (Figure 8). The vegetation groups that fell outside their corresponding confidence interval values were Shrubland, Herbland, and Non-Vegetated/Sparse Vegetation. These three groups, however, were relatively close to the confidence interval values. Overall, there was good agreement between the map-based and inventory-based area estimates, with less than two percent average difference in total area across the eight vegetation groups of the FNF. The error matrices presented later in this report may assist in determining where confusion among vegetation groups might have occurred during the mapping process.

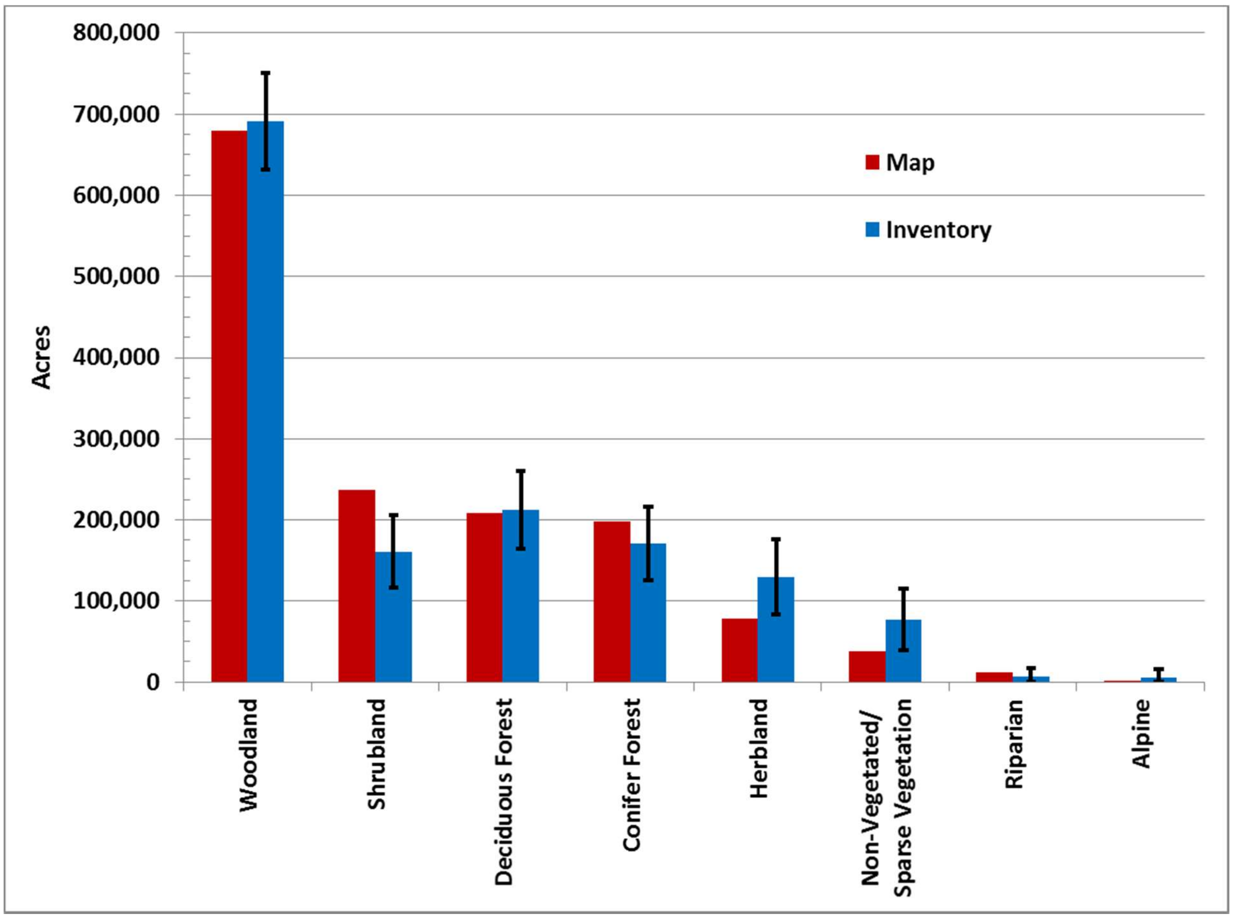


Figure 8: Comparison of mapped and inventory-based estimates of area by vegetation group on the FNF. The 95 percent standard error bars, as derived from the FIESTA program, were added to the inventory-based estimates.

Vegetation Type Comparisons

Vegetation type area estimates were compared between mapped and inventory-predicted areas (Table 16, Figure 9). Note that the vegetation type which covers the largest amount of map acres (Pinyon-Juniper) encompass about 25 percent of the total map area, while the inventory acres cover over 27 percent, which indicates good agreement for the largest vegetation type by this modeling procedure.

The largest difference in percent area for all vegetation types was Gambel Oak, which was predicted over six percent more area on the map compared to the inventory (Table 16, Figure 9, and Figure 10). The second largest difference was Mountain Mahogany, which was predicted by four percent less area on the map than the inventory. There were only three vegetation types with three percent or more differences between their map and inventory-based estimates of area. But overall, the proportion of these differences does not seem very significant compared to the magnitude of the acreage amounts. Note that Ponderosa Pine Mix, Riparian Herbaceous, and Agriculture vegetation types did not have any inventory samples, and consequently do not have any associated inventory acres.

As for the Woodland group, those four vegetation types (Mountain Mahogany, Gambel Oak, Pinyon-Juniper, and Rocky Mountain Juniper Mix) had a respectable overall agreement between the map predictions (46.7 percent) and inventory estimates (47.5 percent), with less than one percent difference between them. Also, those six vegetation types that compose the Conifer Forest group (Bristlecone Pine/Limber Pine, Douglas-fir Mix, Spruce/Fir, Ponderosa Pine Mix, White Fir, and White Fir Mix) had a similar overall agreement between the map predictions (13.7 percent) and the inventory estimates (11.6 percent), with just over two percent difference. However, when the vegetation types for the Woodland and Conifer Forest groups are combined, their overall agreement between map and inventory estimates is just over one percent difference.

In general, comparisons of map units with less than ten inventory plot/conditions are typically not recommended as it may produce unreliable inventory-based area estimates. A more appropriate technique may be to combine some of these map units, when appropriate, so they are represented by a larger number of inventory plot/conditions. Misclassifications and confusion areas will be delineated in the error matrix portion of the report.

Table 16: Mapped versus inventory-based estimates of area by existing vegetation types on the FNF. Acreage and Percent Differences are based on the difference of total area between mapped and inventory estimates. A positive difference indicates estimated mapped acres exceed inventory acres for that class, while a negative difference implies more inventory acres than estimated mapped acres. Vegetation classes are sorted by descending map acres.

Vegetation Class	Code	Map Acres	Map % of Total Area	Inventory Acres	Inventory % of Total Area	Acreage Difference	% Difference
Pinyon-Juniper	PJ	365,928	25.2	395,650	27.2	-29,722	-2.0
Gambel Oak	GO	259,027	17.8	163,299	11.2	95,728	6.6
Aspen/Conifer	AS/C	112,504	7.7	86,798	6.0	25,706	1.7
Mountain Big Sagebrush	MSB	98,294	6.8	78,343	5.4	19,951	1.4
Spruce/Fir	SF	96,503	6.6	75,908	5.2	20,595	1.4
Aspen	AS	95,981	6.6	125,438	8.6	-29,457	-2.0
Upland Herbaceous	UHE	77,429	5.3	129,848	8.9	-52,419	-3.6
Wyoming/Basin Big Sagebrush	WSB/BSB	53,225	3.7	16,486	1.1	36,739	2.6
Mountain Mahogany	MM	47,959	3.3	108,165	7.4	-60,206	-4.1
White Fir Mix	WFmix	38,991	2.7	30,865	2.1	8,126	0.6
Barren/Sparse Vegetation	BR/SV	35,300	2.4	64,148	4.4	-28,848	-2.0
Black Sagebrush	BLSB	33,951	2.3	28,194	1.9	5,757	0.4
Mountain Shrubland	MS	31,835	2.2	26,637	1.8	5,198	0.4
Douglas-fir Mix	DFmix	26,955	1.9	11,983	0.8	14,972	1.1
White Fir	WF	20,260	1.4	41,167	2.8	-20,907	-1.4
Silver Sagebrush	SSB	20,248	1.4	11,388	0.8	8,860	0.6
Ponderosa Pine Mix	PPmix	12,918	0.9	0	0.0	12,918	0.9
Riparian Woody	RW	9,850	0.7	6,364	0.4	3,486	0.3
Rocky Mountain Juniper Mix	RMJmix	6,219	0.4	24,082	1.7	-17,863	-1.3
Bristlecone Pine/Limber Pine	BC/LM	2,656	0.2	10,631	0.7	-7,975	-0.5
Riparian Herbaceous	RHE	2,486	0.2	0	0.0	2,486	0.2
Water	WA	1,939	0.1	9,485	0.7	-7,546	-0.6
Alpine Vegetation	ALP	1,921	0.1	4,826	0.3	-2,905	-0.2
Developed	DEV	524	0.0	3,215	0.2	-2,691	-0.2
Agriculture	AGR	15	0.0	0	0.0	15	0.0
Total		**1,452,917**	**100.0**	**1,452,917**	**100.0**	**n/a**	**n/a**

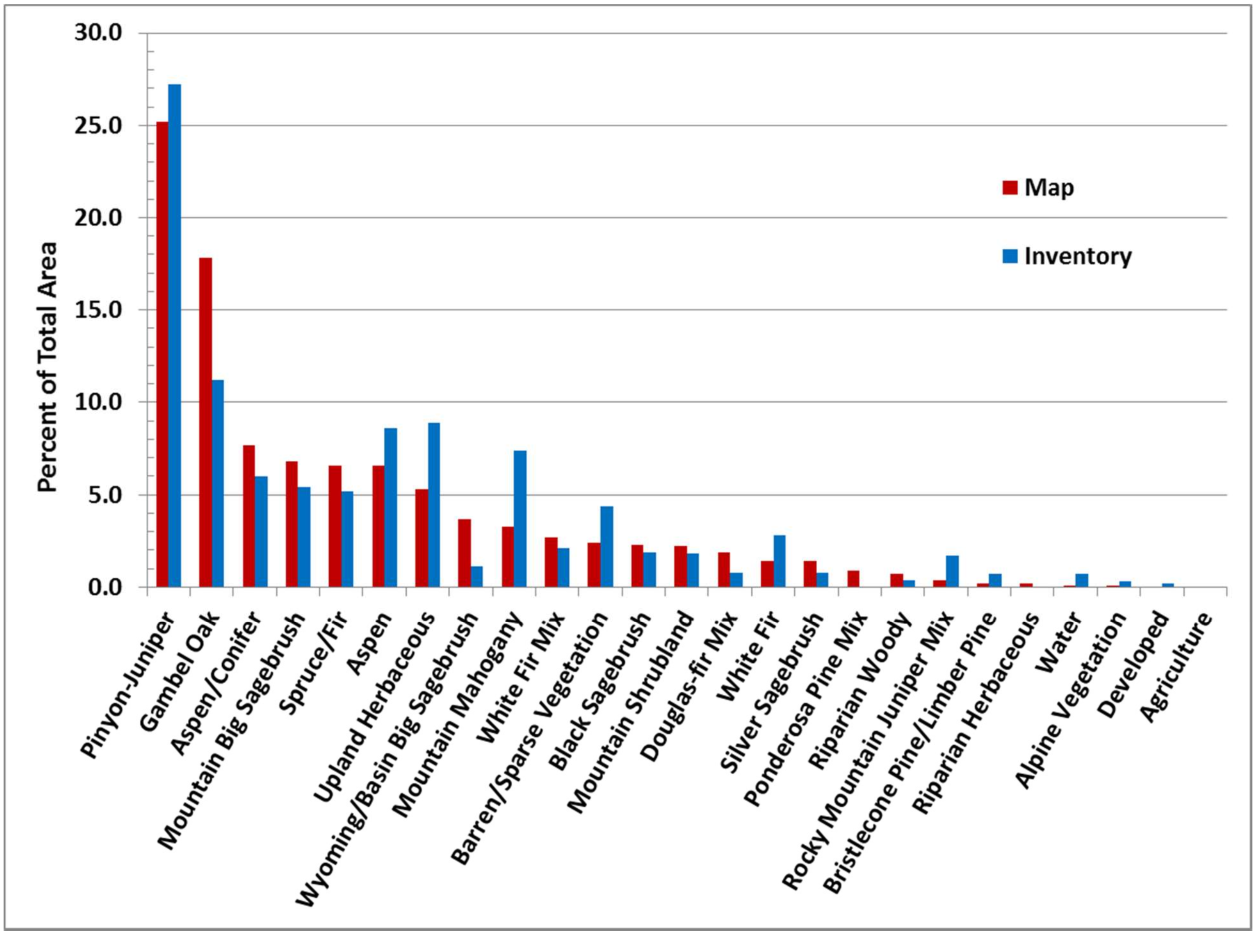


Figure 9: Comparison of mapped and inventory-based estimates of area as a percentage of total area by vegetation type for the FNF.

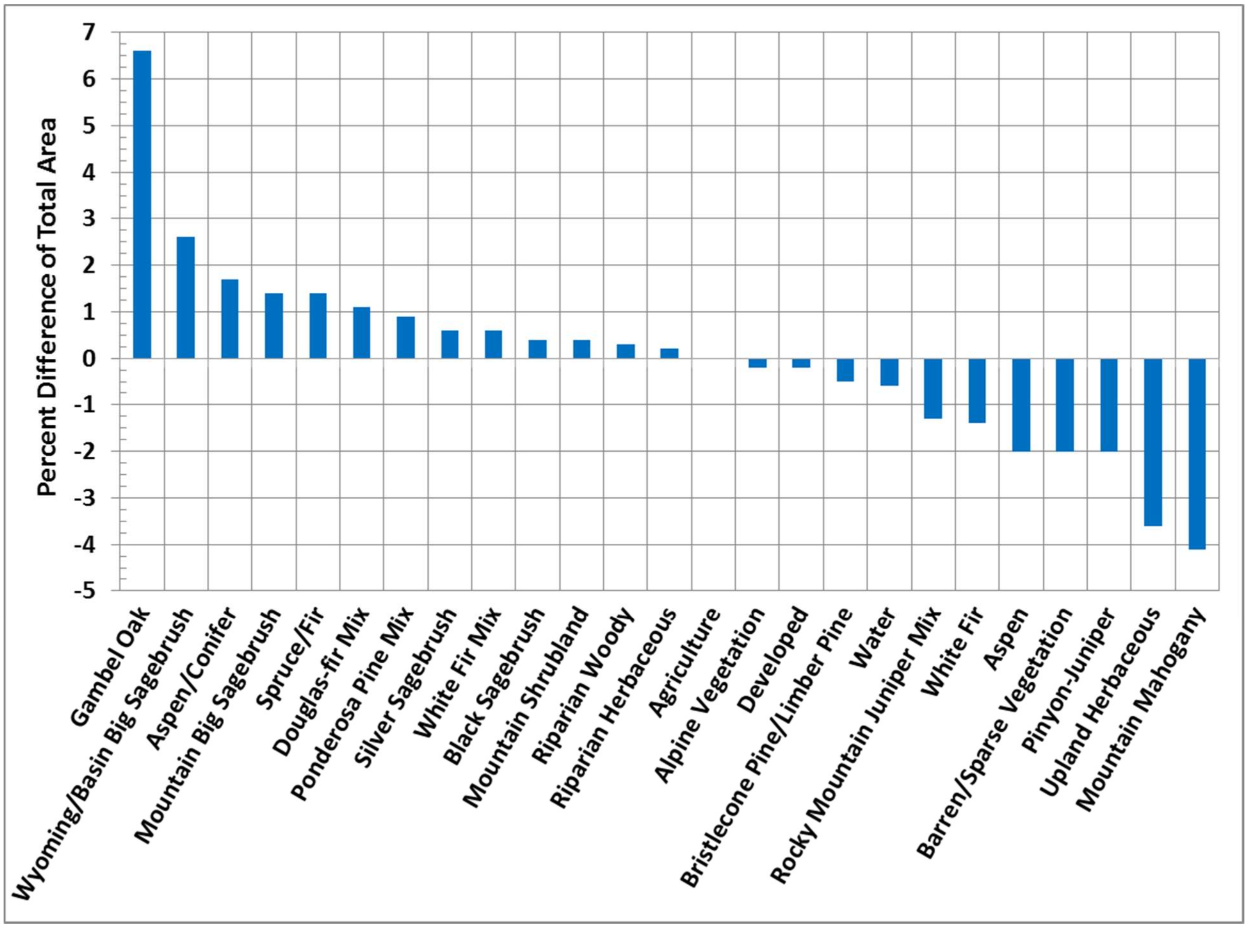


Figure 10: Comparison of mapped and inventory-based estimates of area as a difference in percentage of total area by vegetation type for the FNF**.** A positive difference indicates mapped acres exceed inventory acres for that type, while a negative difference shows that inventory acres surpass mapped acres.

Confidence Interval (95 Percent Standard Error) for Vegetation Types

Using the FIESTA tool to derive 95 percent standard error intervals from the inventory-based area estimates for vegetation types shows some strengths and weaknesses of the mapping process when additional vegetation types are introduced into the modeling process. Comparisons between the mapped areas to their inventory-based confidence intervals are shown in Figure 11.

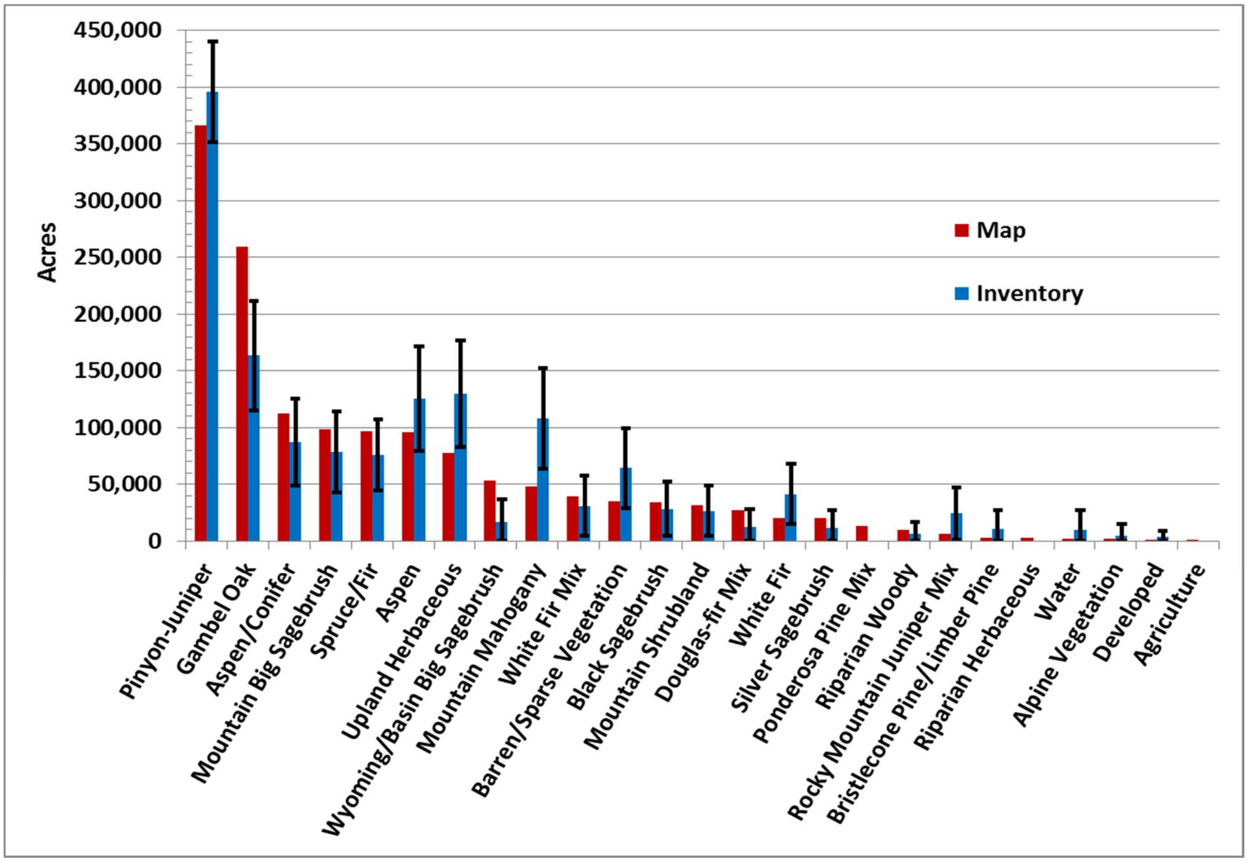


Figure 11: Comparison of mapped and inventory-based estimates of area by vegetation type for the FNF. The 95 percent standard error bars were derived from the inventory-based estimates using FIESTA. Error bars were not generated for Ponderosa Pine Mix, Riparian Herbaceous, or Agriculture, since no FIA plots were sampled in those vegetation types.

The mapped areas of four vegetation types (Gambel Oak, Upland Herbaceous, Wyoming/Basin Big Sagebrush, and Mountain Mahogany) fell outside their corresponding 95 percent standard error intervals, while the remaining 18 vegetation types were within their respective error intervals. Note that the nine largest vegetation types (each over three percent of the mapped area) included these four vegetation types that fell outside their corresponding error intervals. Ponderosa Pine Mix, Riparian Herbaceous, and Agriculture types did not have any inventory samples, and consequently do not have any associated error bars. Moreover, only one of the six largest types (each over six percent of the mapped area), and one of the two largest vegetation types (43 percent of the map area) fell outside its 95 percent standard error interval.

While there were four vegetation types (Gambel Oak, Mountain Mahogany, Upland Herbaceous, and Wyoming/Basin Big Sagebrush) that had over two percent difference between map and inventory acres (Table 16, Figure 10), all four were outside of their respective error interval (Figure 11). There may also be some modeling confusion between Gambel Oak and

Mountain Mahogany, as well as Aspen and Aspen/Conifer types, as some of these include mixtures which potentially may be more troublesome to classify based somewhat on their similar spectral signatures. On the other hand, the vegetation types with relatively larger areas, with the exception of Gambel Oak, were typically within their respective error intervals. But overall, there was good agreement between the map and inventory area estimates of vegetation types for the FNF.

Tree Size Class Comparisons

Map and inventory-based estimates of areas for different forest and woodland tree size (diameter) classes were compared for the FNF (Table 17, Figure 12). The map and inventory acres for the NT (Non Tree) class were comparable, which is always beneficial for a class that covers such a large area (about 25 percent) of the FNF. The WS2 (6 - 11.9” DRC) class was the largest among tree map estimates, with over 29 percent of the total area. The next largest class was FS2 (5 - 11.9” DBH) with 22 percent, followed by WS1 (0 - 5.9” DRC) at 16 percent. These three tree size classes account for 68 percent of the map estimates for total area, while the remaining six tree size classes combined for only six percent. From Figure 12, the map acres tend to be less than the inventory acres for the larger diameter classes (i.e., FS4, FS5, WS3, and WS4), while map acres are more than inventory acres for those three most prevalent diameter classes for the FNF (WS2, FS2, and WS1). The diameter classes having the least amount of agreement between map acres and inventory acres were WS2 (15.1%), WS4 (-13.9%), and WS3 (-6.4%), while the remaining classes were each less than five percent difference.

Table 17: Mapped and inventory-based estimates of area by forest and woodland tree diameter classes for the FNF. Acreage and Percent Differences are based on the difference of total area between mapped and inventory estimates. A positive difference indicates estimated mapped acres exceed inventory acres for that class, while a negative difference implies more inventory acres than estimated mapped acres.

Tree Size Code	Tree Size Class DBH or DRC (in)	Map Acres	Map % of Total Area	Inventory Acres	Inventory % of Total Area	Acreage Difference	% Difference
FS1	0 - 4.9" DBH	9,955	0.7	23,023	1.6	-13,068	-0.9
FS2	5 - 11.9" DBH	331,967	22.8	289,641	19.9	42,326	2.9
FS3	12 - 17.9" DBH	64,457	4.4	41,013	2.8	23,444	1.6
FS4	18 - 23.9" DBH	92	0.0	20,946	1.4	-20,854	-1.4
FS5	≥ 24" DBH	297	0.0	8,167	0.6	-7,870	-0.6
WS1	0 - 5.9" DRC	241,635	16.6	178,880	12.3	62,755	4.3
WS2	6 - 11.9" DRC	422,647	29.1	202,713	14.0	219,934	15.1
WS3	12 - 17.9" DRC	7,123	0.5	100,708	6.9	-93,585	-6.4
WS4	≥ 18" DRC	7,729	0.5	208,893	14.4	-201,164	-13.9
NT	Non Tree	367,017	25.3	378,933	26.1	-11,916	-0.8
Total		**1,452,917**	**100.0**	**1,452,917**	**100.0**	**n/a**	**n/a**

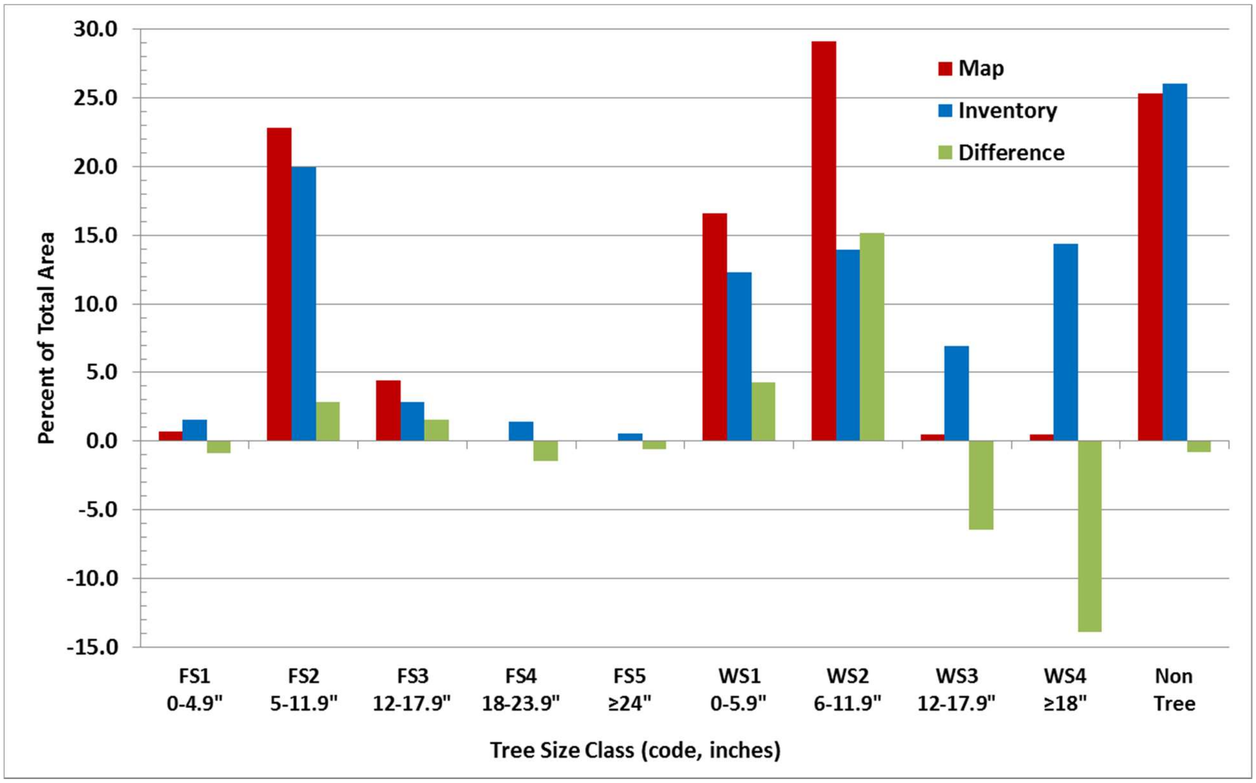


Figure 12: Comparison of mapped and inventory-based estimates of area as a percentage of total area by forest and woodland tree size classes for the FNF. A positive difference indicates estimated mapped acres exceed inventory acres for that class, while a negative difference implies more inventory acres than estimated mapped acres.

Confidence Interval (95 Percent Standard Error) for Tree Size Class

FIESTA-based estimates of 95 percent standard error intervals were generated around the inventory-based area estimates for each of the ten tree size classes. The mapped areas of five tree size classes (FS4, WS1, WS2, WS3, and WS4) fell outside their corresponding 95 percent standard error intervals, while the five remaining classes (FS1, FS2, FS3, FS5, and Non Tree) were within their respective error intervals (Figure 13). However, most of the tree size classes were either within or relatively close in agreement between map acres and the standard error intervals from the inventory-based area estimates. As shown in Figure 13 and Table 17, the tree size classes that were outside of their respective standard error intervals and had a percent difference of more than ten percent in their estimates were WS2 (15.1%) and WS4 (-13.9%). This was primarily due to the relatively high map estimate for WS2 (422,647 acres) compared to its inventory-based estimate (202,713 acres), and the relatively low map estimate for WS4 (7,729 acres) related to its inventory-based estimate (208,893 acres). It is essential to recognize the limitations of mapping and assessing tree size classes, such as estimating tree size from aerial imagery or sampling errors associated with measuring size classes in the field.

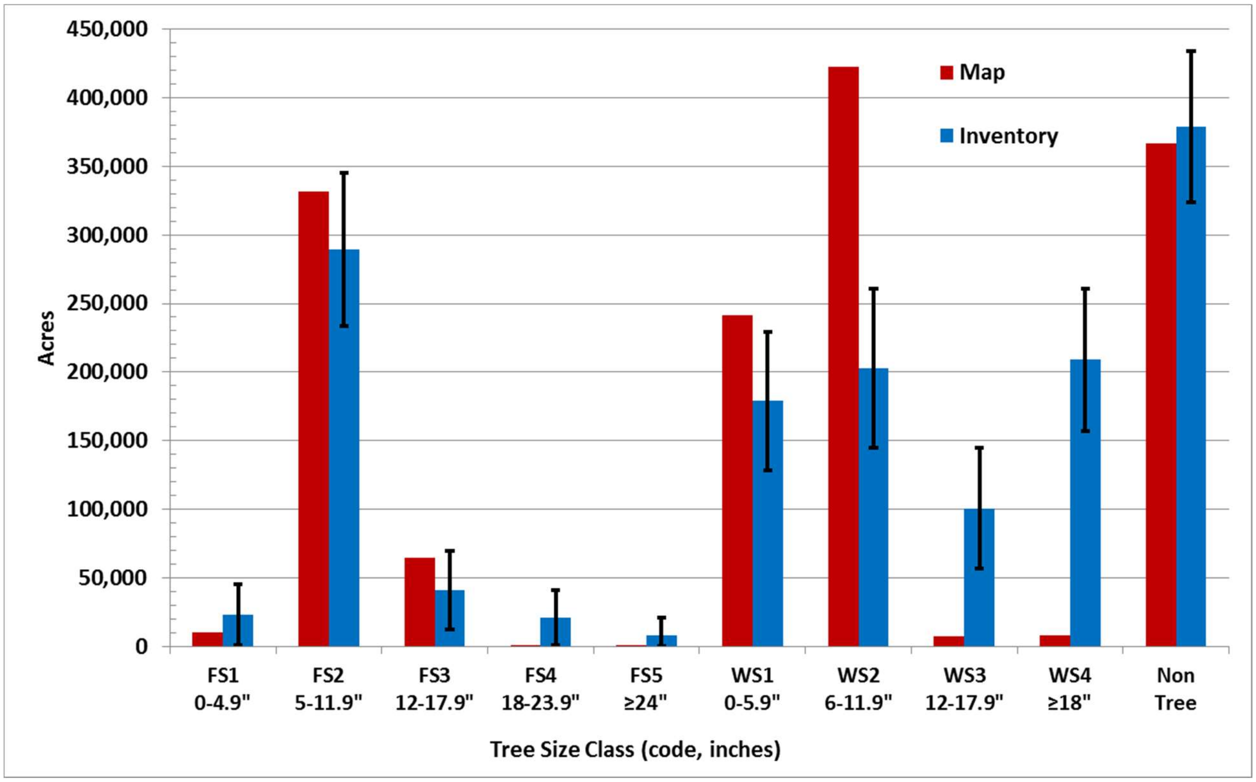


Figure 13: Comparison of mapped and inventory-based estimates of area by tree size classes for the FNF, with 95 percent standard error bars generated from the inventory-based estimates using FIESTA.

Tree Canopy Cover Comparisons

Besides tree size classes, map and inventory-based estimates of areas by different tree canopy cover classes were compared as well (Table 18, Figure 14). The TC5 (≥ 60%) class had the largest difference (-15.8%) between map and inventory estimates, with the map-based estimate (86,412 acres) less than the inventory-based value (315,201 acres). The TC2 (20-39%) class produced the next largest area difference at 13.3 percent, followed by TC1 (10-19%) at 4.6 percent. The remaining tree canopy cover classes were in relatively good agreement between their map and inventory area estimates (each less than two percent difference). The map-based estimates seemed to be over-predicting for a medium tree cover class (TC2), while under-predicting for a more dense class (TC5), when compared to the inventory-based estimates. The modeling procedure may be estimating areas difficult to classify into the most prevalent cover class, such as what seemed to be the case with TC2 (20 - 39%). On the other hand, the map and inventory acres for TC3 (40 - 49%), TC4 (50 - 59%), and NT (Non Tree) canopy classes combined were just over two percent difference, which is notable for three classes that cover such a large area (46 percent total map area) of the FNF.

Table 18: Mapped and inventory-based estimates of area by tree canopy cover class on the FNF. Acreage and Percent Differences are based on the difference of total area between mapped and inventory estimates. A positive difference indicates estimated mapped acres exceed inventory acres for that class, while a negative difference implies more inventory acres than estimated mapped acres.

Canopy Cover Code	Canopy Cover Class	Map Acres	Map % of Total Area	Inventory Acres	Inventory % of Total Area	Acreage Difference	% Difference
TC1	10 - 19%	170,287	11.7	103,412	7.1	66,875	4.6
TC2	20 - 39%	526,035	36.2	332,354	22.9	193,681	13.3
TC3	40 - 49%	182,182	12.5	201,498	13.9	-19,316	-1.4
TC4	50 - 59%	120,982	8.3	121,519	8.4	-537	-0.1
TC5	≥ 60%	86,412	5.9	315,201	21.7	-228,789	-15.8
NT	Non Tree	367,017	25.3	378,933	26.1	-11,916	-0.8
Total		**1,452,917**	**100.0**	**1,452,917**	**100.0**	**n/a**	**n/a**

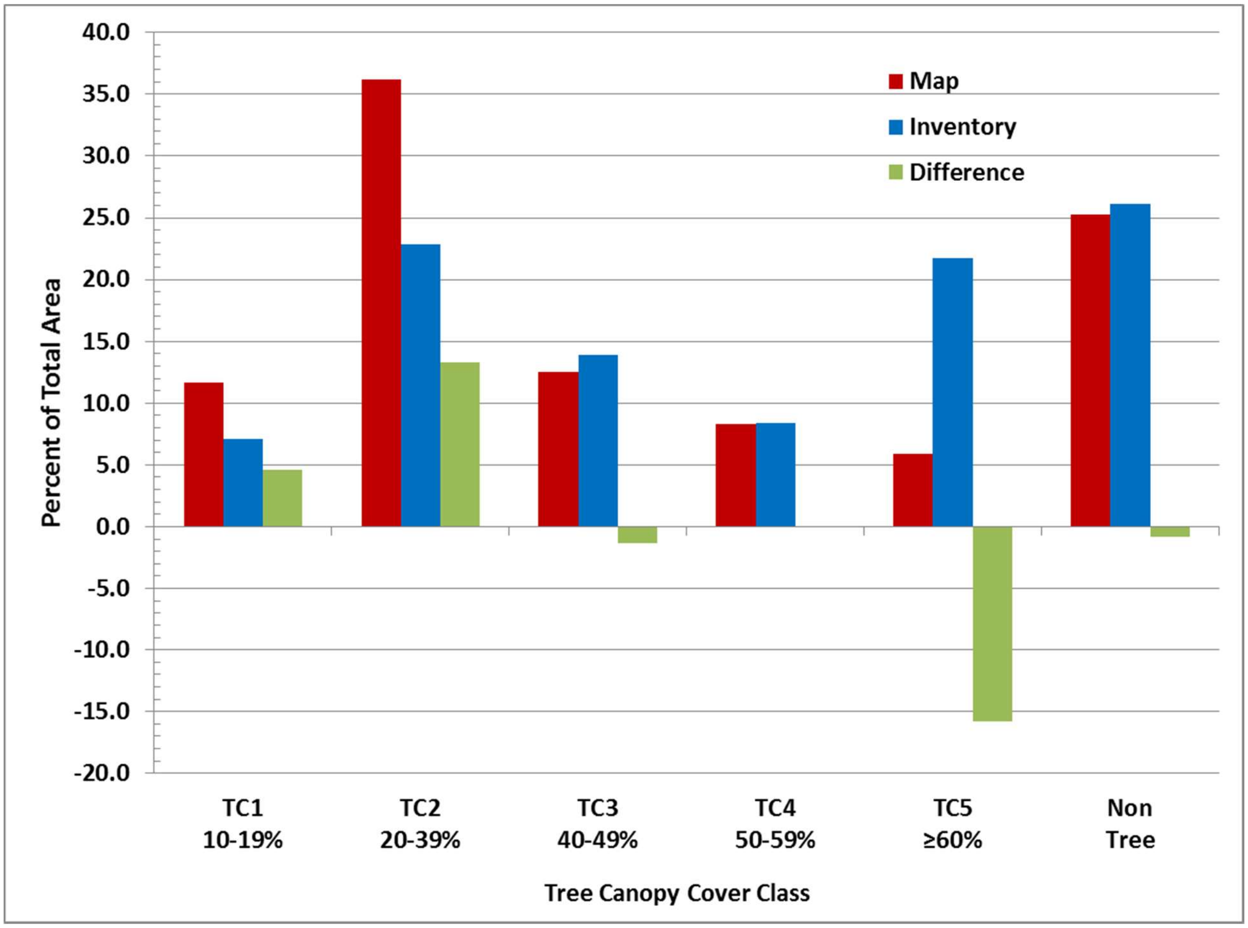


Figure 14: Comparison of mapped and inventory-based estimates of area as a percentage of total area by tree canopy cover classes for the FNF. A positive difference indicates estimated mapped acres exceed inventory acres for that class, while a negative difference implies more inventory acres than estimated mapped acres.

Shrub Canopy Cover Comparisons

In addition to area by tree canopy cover, map and inventory-based estimates of areas for different shrub cover classes were also evaluated (Table 19, Figure 15). Overall, the shrub canopy cover area estimates from the map estimates were somewhat comparable to their respective classes for the inventory-based estimates, with an average difference per class of less than three percent. Map area estimates for two shrub canopy cover classes (SC1 (10 - 24%), SC2 (25 - 34%)) were each within two percent of their inventory-based values, while SC3 (≥ 35%) and NS (Non Shrub) had larger differences (near four and five percent, respectively). In general, there was satisfactory agreement between the map and inventory-based estimates of shrub cover classes.

Table 19: Mapped and inventory-based estimates of area by shrub canopy cover class for the FNF. Acreage and Percent Differences are based on the difference in percentages of total area between mapped and inventory estimates. A positive difference indicates estimated mapped acres exceed inventory acres for that class, while a negative difference implies more inventory acres than estimated mapped acres.

Canopy Cover Code	Canopy Cover Class	Map Acres	Map % of Total Area	Inventory Acres	Inventory % of Total Area	Acreage Difference	% Difference
SC1	10 - 24%	117,979	8.1	92,795	6.4	25,184	1.7
SC2	25 - 34%	46,689	3.2	54,437	3.7	-7,748	-0.5
SC3	≥ 35%	82,735	5.7	25,006	1.7	57,729	4.0
NS	Non Shrub	1,205,514	83.0	1,280,679	88.1	-75,165	-5.2
Total		**1,452,917**	**100.0**	**1,452,917**	**100.0**	**n/a**	**n/a**

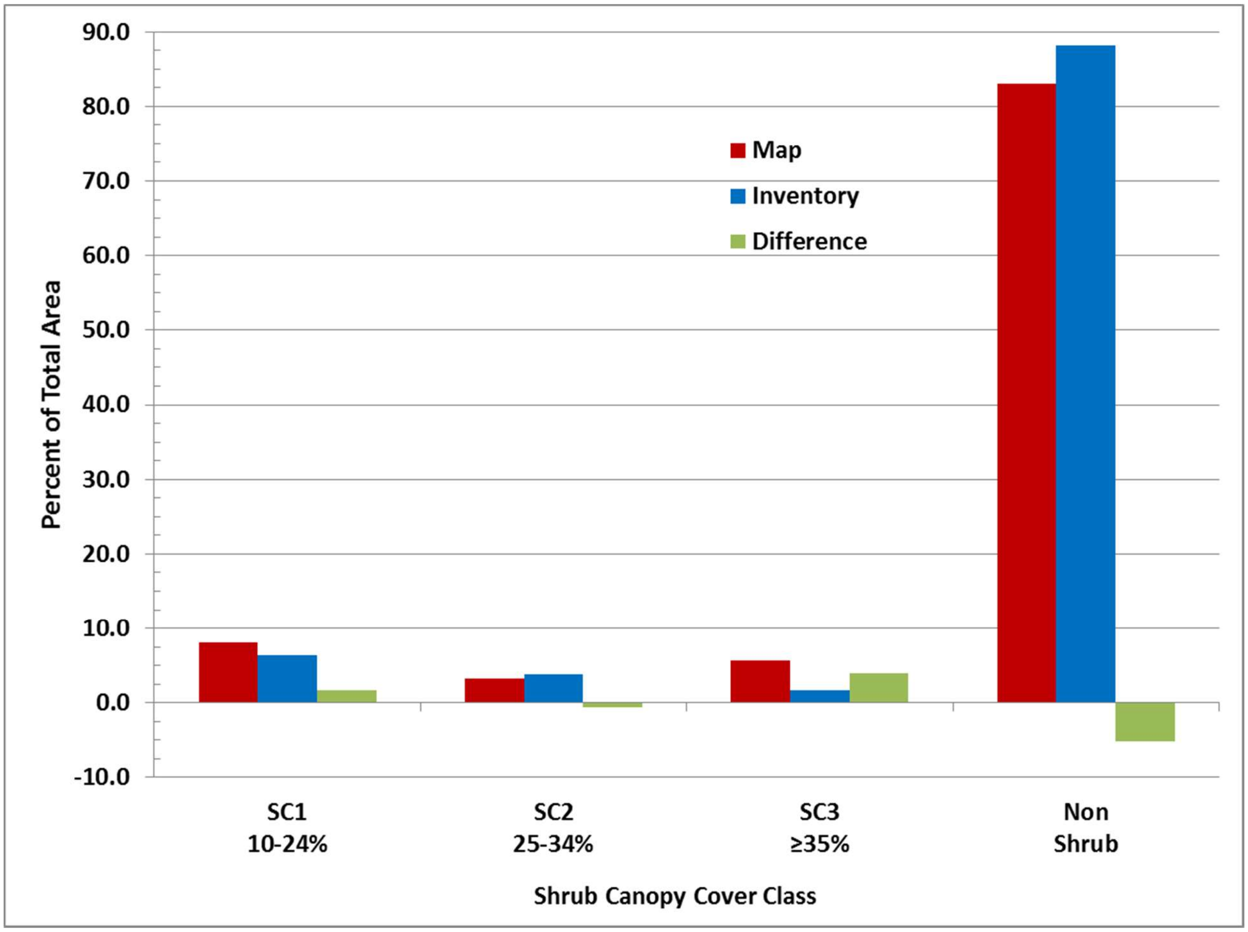


Figure 15: Comparison of mapped and inventory-based estimates of area as a percentage of total area by shrub canopy cover classes for the FNF. A positive difference indicates estimated mapped acres exceed inventory acres for that class, while a negative difference implies more inventory acres than estimated mapped acres.

Confidence Interval (95 Percent Standard Error) for Canopy Cover Class

FIESTA estimates of 95 percent standard error confidence intervals for the inventory-based area estimates were created for each tree and shrub canopy cover class (Figure 16). The four canopy cover classes whose map-based estimates were within their corresponding 95 percent standard error bars were TC3 (40 - 49%), TC4 (50 - 59%), SC1 (10 - 24%), and SC2 (25 - 34%), each with less than two percent difference in area estimates. The remaining five cover classes were outside their respective error bars, ranging from four percent to almost 16 percent differences in acreage estimates (Tables 18 and 19). Note that the average difference in area estimates among the four canopy cover classes inside their corresponding error bars (0.9 percent), as compared to the five classes outside their error bars (8.7 percent), was very disparate. Overall, both the tree and shrub canopy cover classes generally varied in agreement between their map and inventory acreage estimates, with an average difference per class of over five percent.

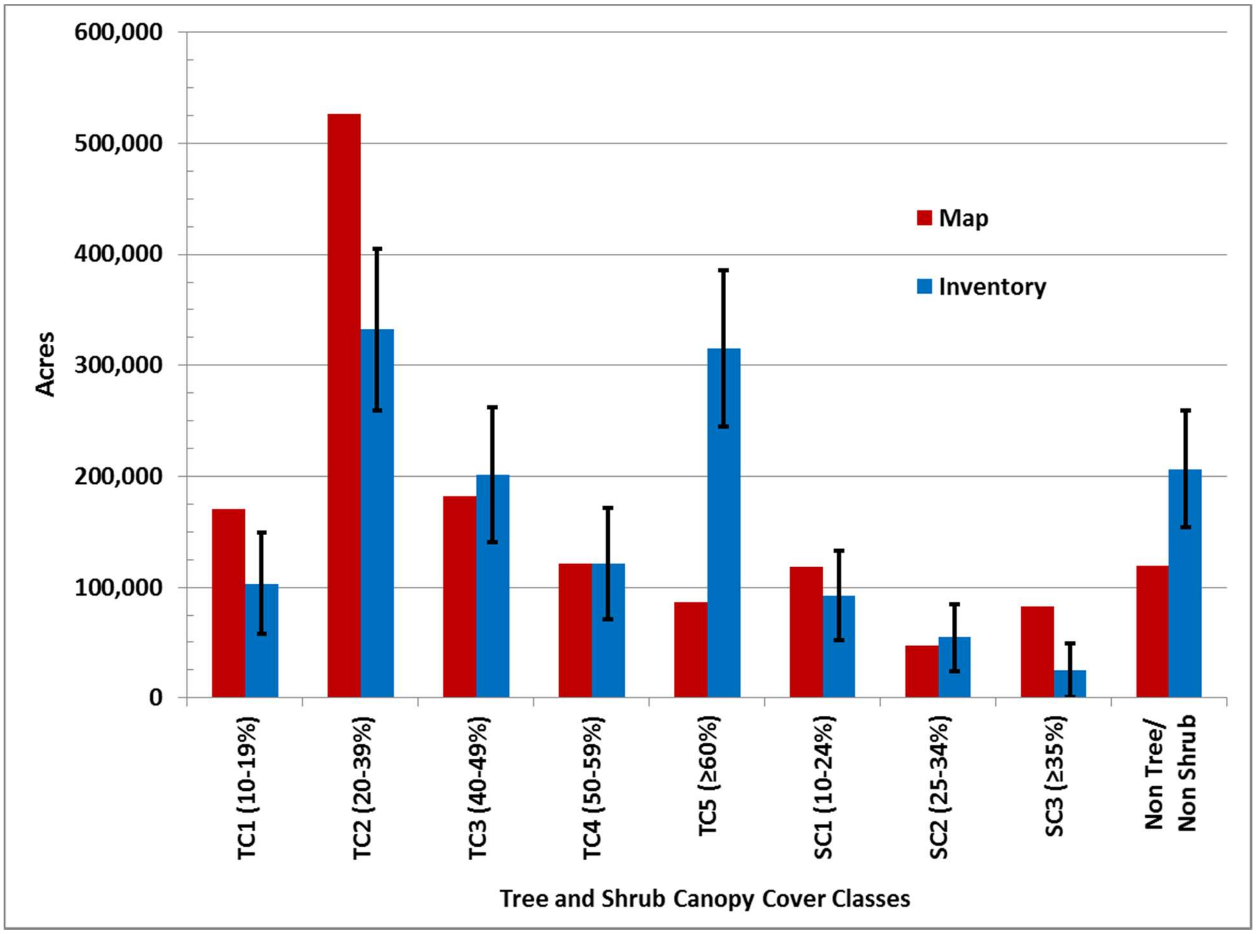


Figure 16: Comparison of mapped and inventory-based estimates of area by canopy cover classes for the FNF, with 95 percent standard error bars generated from the inventory-based estimates using FIESTA.

Site-Specific Accuracy Assessment

Accuracy assessments are an essential part of any modeling or remote sensing project; not only for comparing different mapping methods and sensors, but also for providing information on the reliability and usefulness of those techniques for a particular application. More importantly, accuracy assessments provide guidance in the decision making process by providing a measure of reliability for the mapped classes, as well as allowing users to understand a map's limitations (Nelson et al. 2015).

Error Matrix

The error (confusion) matrix is a standard tool used for presenting results of an accuracy assessment. In general, it is a square array where both the classified reference (observed) and image (mapped) data are ordered and compared for class agreement on the diagonally intersected cells; typically rows in the matrix represent the classified image data while columns represent the observed data (Story and Congalton 1986). The error matrix can be used to determine the accuracy of classes and any degree of confusion between classes.

The vegetation group error matrix for the FNF is presented in Table 20, with the observed classes (FIA inventory plots) in the columns and the mapped classes (modeled results) in the rows. For accuracy assessment purposes, only the condition-level data from the center subplot of an FIA plot (Appendix I) was used, since it corresponds to the actual coordinates used when intersecting an FIA plot against mapped values. As a result, a total of 243 FIA plot/conditions were available for the following accuracy assessment tables, instead of the 288 sampled plot/conditions previously stated (e.g., some FIA plots had multiple-conditions per plot or did not have a center subplot accessible to field crews). The highlighted diagonal cells tally the number of inventory plots that are in agreement with the intersected mapped classes. Percent class accuracies were calculated by dividing the number of correct classifications (diagonal cells) by each class total.

Table 20: Error matrix for vegetation groups on the FNF. FIA plots were used as an independent source to evaluate the classification accuracies of the modeled map classes. Overall classification accuracy across eight vegetation groups was 78 percent, while average producer's accuracy was 49 percent and average user's accuracy was 51 percent. The Kappa statistic was 69 percent.

		INVENTORY PLOTS									
	Map Group	**Woodland**	**Deciduous Forest**	**Shrubland**	**Conifer Forest**	**Herbland**	**Non-Vegetated/ Sparse Vegetation**	**Riparian**	**Alpine**	**Total**	**User's % Accuracy**
MAP CLASS	**Woodland**	**104**	3	2	2	2	2			115	**90**
	Deciduous Forest	1	**32**	1	6	1				41	**78**
	Shrubland	6		**22**	1	6	3			38	**58**
	Conifer Forest	3	3		**19**	1				26	**73**
	Herbland	1		1		**11**	4	1	1	19	**58**
	Non-Vegetated/Sparse Veg		1			1	**2**			4	**50**
	Riparian									0	**0**
	Alpine									0	**0**
	Total	115	39	26	28	22	11	1	1	**243**	**51**
	Producer's % Accuracy	**90**	**82**	**85**	**68**	**50**	**18**	**0**	**0**	**49**	**78**

The overall accuracy for an error matrix is determined by summing the number of correct classifications (diagonal cells) and dividing that sum by the total number of observations (FIA plot/conditions in this case). While the overall accuracy summarizes the actual agreement between map and inventory classifications, the Kappa statistic indicates the difference between the observed accuracy and the amount of agreement due to random chance. Consequently, the Kappa statistic may provide a meaningful measure of agreement between the map and inventory classifications without chance. The Kappa statistic (K) for an error matrix is calculated by the following formula (Lillesand and Kiefer 1994):

$$K = (\text{observed accuracy - chance agreement}) / (1 - \text{chance agreement})$$

There are two main types of accuracies generated for each class in an error matrix: a user's and producer's accuracy. A user's accuracy indicates errors of commission, where a class has been mapped in places where it does not exist. A producer's accuracy indicates errors of omission, where a class has not been mapped where it exists on the ground. A user's accuracy value reflects how useful some map product might be for a given user, while a producer's accuracy typically indicates how well some map product represents field samples on the ground. It is generally assumed that at least ten observations per class are needed to have a meaningful value. A "not applicable" (n/a) status was used to indicate when information for a certain cell calculation is not available, which is primarily due to the absence of inventory plots for a specific row or column in the error matrix.

Vegetation Group Accuracies

As shown in Table 20, the vegetation group with the highest producer's accuracy was the Woodland group (90 percent). The Shrubland group was comparable with 85 percent, followed by the Deciduous Forest group at 82 percent. The Conifer Forest group was next with an accuracy of 68 percent, while Herbland and Non-Vegetated/Sparse Vegetation groups had lower accuracies. Alpine (zero percent) and Riparian (zero percent) groups each had only one plot/condition.

The Woodland group had the highest user's accuracy at 90 percent, which was the highest class accuracy shown in Table 20, followed by the Deciduous Forest group at 78 percent. The Conifer Forest (73 percent), Shrubland (58 percent), and Herbland (58 percent) groups had slightly lower accuracies, while the remaining groups were at 50 percent or less.

Some issues related to mapping involve separating "fuzzy" categorical boundaries between different mapping groups. Generally, it is difficult to accurately separate groups within transition zones. In addition, inventory plots and vegetation group polygons may encompass multiple vegetation groups, leading to additional confusion. The overall classification accuracy for the eight vegetation groups was 78 percent, while the average producer's accuracy was 49 percent and average user's accuracy was 51 percent. The Kappa statistic was 69 percent.

Vegetation Type Accuracies

Accuracy assessment results typically decrease when the complexity of mapping more refined classes occurs. The overall classification accuracies for 25 vegetation types (Table 21) should consequently be lower than that for eight vegetation groups (Table 20). As expected, accuracies decline due, in part, to a larger number of classes and distinctions made to account for a greater variety of vegetation types. The overall accuracy for the 25 vegetation types was 61 percent, while average producer's accuracy was 41 percent and average user's accuracy was 38 percent. The vegetation types of Agriculture, Developed, Ponderosa Pine Mix, and Riparian Herbaceous had zero plots/conditions; therefore, those types did not affect and were not included in the overall classification accuracy. The Kappa statistic was 56 percent.

The vegetation types listed in Table 21 were ordered and shaded by their corresponding vegetation groups (Table 20), so that any misclassifications within members of an individual vegetation group could be easily detected. For example, the four vegetation types within the Woodland vegetation group (Mountain Mahogany, Gambel Oak, Pinyon-Juniper, and Rocky Mountain Juniper Mix) were grouped together and have a light-brown shading in Table 21. Those plot misclassifications within this Woodland group “box” could be considered as having a reasonable justification of being misclassified by being within the same vegetation group. Alternatively, misclassifications of plots along the columns of those woodland types, but outside this Woodland group “box”, are probably not as easily justified and may indicate some modeling deficiency that needs further review.

Table 21: Error matrix for vegetation types on the FNF. FIA plots were used as a validation data set to produce the classification accuracies of the modeled map unit classes. Overall classification accuracy across 25 vegetation types was 61 percent, while average producer’s accuracy was 41 percent, and average user’s accuracy was 38 percent. The Kappa statistic was 56 percent.

MAP CLASS	INVENTORY PLOTS																										
Map Unit	Alpine Vegetation	Riparian Herbaceous	Riparian Woody	Upland Herbaceous	Wyoming/Basin Big Sagebrush	Black Sagebrush	Mountain Big Sagebrush	Silver Sagebrush	Mountain Shrubland	Mountain Mahogany	Gambel Oak	Pinyon-Juniper	Rocky Mountain Juniper Mix	Aspen	Aspen/Conifer	Ponderosa Pine Mix	Douglas-fir Mix	White Fir	White Fir Mix	Spruce/Fir	Bristlecone Pine/Limber Pine	Barren/Sparse Vegetation	Agriculture	Developed	Water	Total	User's % Accuracy
Alpine Vegetation																										0	**0**
Riparian Herbaceous																										0	**n/a**
Riparian Woody																										0	**0**
Upland Herbaceous	1		1	**11**	1						1											4				19	**58**
Wyoming/Basin Big Sagebrush				2	**1**		1					1										2				7	**14**
Black Sagebrush				1		**2**	3					1														7	**29**
Mountain Big Sagebrush				2		1	**8**		2		1	2							1							17	**47**
Silver Sagebrush				1		1		**2**																		4	**50**
Mountain Shrubland									**1**		1											1				3	**33**
Mountain Mahogany										**3**	1	4	2					1								11	**27**
Gambel Oak				2	1				1	8	**26**	2	1	3					1			1				46	**57**
Pinyon-Juniper										2		**52**	1									1				56	**93**
Rocky Mountain Juniper Mix												2														2	**0**
Aspen											1			**16**	3			1			1					22	**73**
Aspen/Conifer				1			1							1	**12**		1			3						19	**63**
Ponderosa Pine Mix																										0	**n/a**
Douglas-fir Mix																			1							1	**0**
White Fir										1								**1**								2	**50**
White Fir Mix				1						2				1				1								5	**0**
Spruce/Fir															2		1	1	1	**12**	1					18	**67**
Bristlecone Pine/Limber Pine																										0	**0**
Barren/Sparse Vegetation				1										1								**1**				3	**33**
Agriculture																										0	**n/a**
Developed																										0	**n/a**
Water																									**1**	1	**100**
Total	1	0	1	22	3	4	13	2	4	16	31	64	4	22	17	0	2	5	4	15	2	10	0	0	1	**243**	**38**
Producer's % Accuracy	**0**	**n/a**	**0**	**50**	**33**	**50**	**62**	**100**	**25**	**19**	**84**	**81**	**0**	**73**	**71**	**n/a**	**0**	**20**	**0**	**80**	**0**	**10**	**n/a**	**n/a**	**100**	**41**	**61**

Pinyon-Juniper vegetation type had the highest number of inventory plots (64), with a producer's accuracy of 81 percent and user's accuracy of 93 percent. The modeling process seemed to perform well for this vegetation type. The next most numerous vegetation type was Gambel Oak (31 plots), which had a producer's accuracy of 84 percent but a user's accuracy of 57 percent. This difference in producer and user accuracy values may indicate potential confusion among other types; primarily Upland Herbaceous, Mountain Big Sagebrush, Mountain Shrubland, Mountain Mahogany, and Aspen. The remaining vegetation types with ten or more samples were Upland Herbaceous (22 plots), Aspen (22 plots), Aspen/Conifer (17 plots), Mountain Mahogany (16 plots), Spruce/Fir (15 plots), Mountain Big Sagebrush (13 plots), and Barren/Sparse Vegetation (10 plots).

For producer's accuracy values, vegetation types with 50 percent accuracy or more included: Silver Sagebrush (100 percent, two plots), Water (100 percent, one plot), Gambel Oak (84 percent), Pinyon-Juniper (81 percent), Spruce/Fir (80 percent), Aspen (73 percent), Aspen/Conifer (71 percent), Mountain Big Sagebrush (62 percent), Upland Herbaceous (50 percent), and Black Sagebrush (50 percent, four plots). For the user's accuracy, vegetation types with 50 percent accuracy or more were: Water (100 percent, one plot), Pinyon-Juniper (93 percent), Aspen (73 percent), Spruce/Fir (67 percent), Aspen/Conifer (63 percent), Upland Herbaceous (58 percent), Gambel Oak (57 percent), Silver Sagebrush (50 percent, four plots), and White Fir (50 percent, two plots). Those vegetation types with fewer than ten plots were noted since they have the potential to obtain relatively high accuracies if only a few plots are correctly classified and plots from other types are not mistakenly classified into that particular type.

A map modeling process may be evaluated by reviewing how the model mapped an individual vegetation type. For example, the Pinyon-Juniper type had the highest number of plots (64) in the FIA data set, with 52 of those plots correctly classified by the model. The Pinyon-Juniper type also had a producer's accuracy of 81 percent and user's accuracy of 93 percent. However, by reviewing the Inventory Plots/Pinyon-Juniper column, there were several other modeled vegetation types that overlap with Pinyon-Juniper plots. Three map unit classes that were confused, but perhaps reasonably misclassified by being within the same vegetation group (note the beige shading for the Woodland group "box"), were Mountain Mahogany (four plots), Gambel Oak (two plots), and Rocky Mountain Juniper Mix (two plots). Some map unit classes that were perhaps not reasonably misclassified as Pinyon-Juniper included Wyoming/Basin Big Sagebrush (one plot), Black Sagebrush (one plot), and Mountain Big Sagebrush (two plots).

A similar evaluation could be done while looking along the Map Class/Pinyon-Juniper row, where there are several other vegetation classes with inventory plots whose coordinates intersected within the modeled Pinyon-Juniper vegetation type. Some inventory plot classes that were located within the modeled Pinyon-Juniper vegetation type, which could reasonably be misclassified by being within the same vegetation group (note the light-brown Woodland group “box”), were Mountain Mahogany (two plots) and Rocky Mountain Juniper Mix (one plot). One map unit class that was perhaps not practically misclassified as Pinyon-Juniper was Barren/Sparse Vegetation (one plot). A map user may compare other map classes in a similar manner to determine the level of agreement between a specific modeled map class and its corresponding FIA plot data. A user may also compare producer versus user accuracy values for a specific vegetation type to analyze similarities or differences between the two accuracy values.

It should also be noted that there are several class accuracies with either a 100 percent or zero percent accuracy (Table 21), which is a common occurrence for an individual vegetation class with very few plots. A better representation of model performance might be gained for such cases by collapsing similar vegetation types so some minimum number of plots (perhaps at least ten plots) were available for each class. For example, the Conifer Forest vegetation types of Ponderosa Pine Mix (zero plots), Douglas-fir Mix (two plots), White Fir (five plots), and White Fir Mix (four plots) could be combined into a single “mix” class that would then contain 11 plots.

Tree Size Class Accuracies

For the various tree size classes (excluding the Non Tree class), the FS2 (5 - 11.9" DBH) class had the highest producer’s accuracy (86 percent) and the highest user’s accuracy (74 percent) for the FNF (Table 22). Next, the WS1 (0 - 5.9" DRC) class had the second highest producer’s accuracy (79 percent), while the FS1 (0 - 4.9” DBH) class had the second highest user’s accuracy (67 percent). The WS2 (6 - 11.9” DRC) class had the third highest producer’s accuracy (72 percent), and WS1 (0 - 5.9” DRC) the third highest user’s accuracy (58 percent). All of the remaining tree size classes were 50 percent or less.

The modeling process for the larger-sized tree size classes performed well-below the overall classification accuracy (60 percent). For example, the producer’s accuracy values for forest tree size classes of 18” diameter or larger (FS4 (18 - 23.9" DBH), FS5 (≥ 24.0" DBH)) was zero percent, while the woodland tree size classes of 12” diameter or larger (WS3 (12 - 17.9” DRC), WS4 (≥ 18" DRC)) was also zero percent. In addition, the user’s accuracy values for those four classes were zero percent as well. Overall, the modeling process seemed to underestimate most tree size classes, tending to predict tree diameter values into smaller diameter classes.

Table 22: Error matrix for tree size classes on the FNF. FIA plots were used as a validation data set to produce the classification accuracies for the modeled tree size map classes. Overall classification accuracy across ten tree size classes was 60 percent, while average producer's accuracy was 40 percent, and average user's accuracy was 35 percent. The Kappa statistic was 52 percent.

		INVENTORY PLOTS											
	Tree Size Class (DBH or DRC, inches)	**FS1 (0 - 4.9" DBH)**	**FS2 (5 - 11.9" DBH)**	**FS3 (12 - 17.9" DBH)**	**FS4 (18 - 23.9" DBH)**	**FS5 (≥ 24.0" DBH)**	**WS1 (0 - 5.9" DRC)**	**WS2 (6 - 11.9" DRC)**	**WS3 (12 - 17.9" DRC)**	**WS4 (≥ 18" DRC)**	**Non Tree**	**Total**	**User's % Accuracy**
MAP CLASS	**FS1 (0 - 4.9" DBH)**	**2**	1									3	**67**
	FS2 (5 - 11.9" DBH)	2	**42**	5	1	1		3	1		2	57	**74**
	FS3 (12 - 17.9" DBH)		3	**2**	1						1	7	**29**
	FS4 (18 - 23.9" DBH)											0	**0**
	FS5 (≥ 24.0" DBH)											0	**0**
	WS1 (0 - 5.9" DRC)		2	1	1	1	**26**	5	4	1	4	45	**58**
	WS2 (6 - 11.9" DRC)						4	**23**	9	31	2	69	**33**
	WS3 (12 - 17.9" DRC)									1		1	**0**
	WS4 (≥ 18" DRC)											0	**0**
	Non Tree		1		1		3	1	2	1	**52**	61	**85**
	Total	4	49	8	4	2	33	32	16	34	61	**243**	**35**
	Producer's % Accuracy	**50**	**86**	**25**	**0**	**0**	**79**	**72**	**0**	**0**	**85**	**40**	**60**

Neither DBH nor DRC diameter values are readily determinable using imagery from above; therefore, class separation relies heavily on shared spectral characteristics of similarly sized classes. It is generally more difficult to remotely estimate tree diameters for woodland species (compared to forest species), since their tree form typically does not fit into a consistent diameter-to-crown ratio. In addition to diameter ranges, some degree of confusion can be attributed to misclassification between forest and woodland species as well. Overall classification accuracy across all ten tree size classes was 60 percent, while average producer's accuracy was 40 percent, and average user's accuracy was 35 percent. The Kappa statistic was 52 percent.

Canopy Cover Class Accuracies

The overall classification accuracy across nine canopy cover classes was 40 percent, while average producer's accuracy was 39 percent, and average user's accuracy was 38 percent for the FNF (Table 23). The Kappa statistic was 29 percent. For the various percent canopy cover classes, the TC2 (20 - 39%) class had the highest producer's accuracy (69 percent), while TC5 (≥ 60%) was the most abundant class (56 of 243 plots) followed by the TC2 (20 - 39%) class (55 plots). The remaining classes had lower producer's accuracy values and fewer numbers of plots (34 or less). For the user's percent accuracy values, the Non Tree/Non Shrub class had the highest accuracy (78 percent), followed by the TC5 (≥ 60%) class at 53 percent and the TC2 (20 - 39%) class at 45 percent. The remaining classes had 36 percent or less user's accuracy values with fewer plot counts as compared to TC2 (85 plots). This is also supported by Table 14, which shows the TC2 (20 - 39%) class as the most prevalent class by area (23 percent) for the FNF.

Table 23: Error matrix for canopy cover classes on the FNF. FIA plots were used as a validation data set to produce the classification accuracies for the modeled canopy cover map classes. Overall classification accuracy across nine canopy cover classes was 40 percent, while average producer's accuracy was 39 percent, and average user's accuracy was 38 percent. The Kappa statistic was 29 percent.

		INVENTORY PLOTS										
	Canopy Class (percent cover)	**TC1 (10 – 19%)**	**TC2 (20 - 39%)**	**TC3 (40 - 49%)**	**TC4 (50 - 59%)**	**TC5 (≥ 60%)**	**SC1 (10 - 24%)**	**SC2 (25 - 34%)**	**SC3 (≥ 35%)**	**Non Tree/Non Shrub**	**Total**	**User's % Accuracy**
MAP CLASS	**TC1 (10 - 19%)**	**5**	8	1	2					2	18	**28**
	TC2 (20 - 39%)	3	**38**	14	7	17	1	1		4	85	**45**
	TC3 (40 - 49%)	2	1	**8**	5	16		1			33	**24**
	TC4 (50 - 59%)	1	1	8	**4**	13					27	**15**
	TC5 (≥ 60%)		3	3	3	**10**					19	**53**
	SC1 (10 - 24%)	3	2				**9**	3	1	7	25	**36**
	SC2 (25 - 34%)						3	**2**	1	1	7	**29**
	SC3 (≥ 35%)	1	1					1	**2**	1	6	**33**
	Non Tree/Non Shrub	1	1				3			**18**	23	**78**
	Total	16	55	34	21	56	16	8	4	33	**243**	**38**
	Producer's % Accuracy	**31**	**69**	**24**	**19**	**18**	**56**	**25**	**50**	**55**	**39**	**40**

The modeling process for denser tree canopy cover classes appeared to be somewhat challenging. The producer's accuracy values for the three tree canopy cover classes of 40 percent or more (TC3 (40 - 49%), TC4 (50 - 59%), TC5 (≥ 60%)) were less than those from the two classes below 40 percent canopy cover (TC1 (10 - 19%), TC2 (20 - 39%)). However, the user's accuracy values for those denser tree canopy cover classes were somewhat improved, especially for TC5 (≥ 60%) at 53% but with far fewer plots (19). From Table 23, it appears that denser tree cover classes were typically underestimated and placed in the TC2 (20 - 39%) class.

For the shrub canopy cover classes, both SC2 (25 - 34%) and SC3 (≥ 35%) had relatively few plots (eight and four, respectively), which can result in unreliable estimates with relatively low or high accuracy values. For example, SC2 (25 - 34%) had a producer's accuracy of 25 percent and a user's accuracy of 29 percent. Also, SC3 (≥ 35%) did somewhat better with 50 and 33 percent accuracies, respectively. More representative estimates might be gained by either combining classes with relatively low plot counts or obtaining additional samples.

It is also generally accepted that canopy cover classes can be classified more precisely than tree size (diameter) classes when using remotely-sensed imagery. However, when comparing canopy cover (Table 23) and tree size (Table 22) accuracies (average producer's, average user's, and overall classification), it seems that tree size classes were modeled about the same or perhaps more successfully than canopy cover classes for the FNF. These values might increase by combining some classes, so that ten or more plots per class are available for both modeling purposes and the accuracy assessment. Besides canopy cover class breakpoints, some degree of confusion can be credited to misclassification between tree and shrub species as well.

Conclusions for Accuracy Assessment

Since its inception in the early 1980s, thematic accuracy assessment of remote sensing data has consistently been a particularly challenging portion of the mapping process. Despite its critical importance, there are a wide variety of data types and methods that can be used to attain relatively similar goals. Although a number of definitive standards have been adopted throughout the remote sensing community over the years, there still remains a great degree of uncertainty to the question of how best to perform a reliable, repeatable, and realistic accuracy assessment.

Although optimum reference datasets for accuracy assessment would be designed specifically for use with the final map product, this is often very cost prohibitive and time-consuming. The use of inventory data, such as FIA, involves trade-offs between resolution and reliability. FIA data provide a statistically robust, spatially distributed, unbiased sample that is readily available as a source of information that can serve as a base-level accuracy assessment for mid-level mapping. When used for accuracy assessments, consideration should be given to address differences in the sample design and data collection methods compared with the map products.

Overall, the FNF accuracy assessment results were comparable to assessments conducted on mid-level mapping projects from other Region 4 Forests.

Project Data Files

Feature Class and Layer Files

The existing vegetation polygon feature class and its Federal Geographic Data Committee (FGDC)-compliant metadata are stored and maintained in ESRI geodatabase format within individual forest Enterprise Geodatabase schemas at the Forest Service Enterprise Data Center. This feature class containing a union of vegetation type, tree and shrub cover class, and tree size class serves as the authoritative source data. It is recommended that the feature class be accessed by Forest Service users through Citrix using ESRI ArcGIS software applications to optimize performance (https://citrix.fs.usda.gov/Citrix/StoreWeb/). Geodatabase Feature classes and ArcGIS layer files (*.lyr) containing polygon-feature symbology for vegetation type, cover class, and tree size class can be accessed through Citrix from ArcGIS applications at: T:\FS\NFS\R04\Collaboration\VCMQ\Fishlake\GIS\VegMapping\Maps_Final. To access maps from the Teasdale Ranger District, navigate to: T:\FS\Reference\GIS\r04_dif\Data\VCMQVegExistingMidLevel.gdb\DNF_VegExistingMidLevel. More information on procedures for accessing geospatial data through Citrix at the Data Center can be found at: http://fsweb.egis.fs.fed.us/EGIS_tools/GettingStartedEDC.shtml.

Ancillary and Intermediate Data

All other data related to this project, including ancillary and intermediate geospatial data, reference site information, and supporting documentation are stored and archived as the trusted source data set on the Intermountain Regional Office local Network Attached Storage (NAS) device and tape backup system. Assistance in accessing the authoritative source data through Citrix or obtaining a copy of ancillary and intermediate data sets may be facilitated by Regional Office project partners.

Conclusion

The status and condition of existing vegetation on the FNF is a critical factor for many of its land-management decisions. When used in conjunction with the associated maps, taxonomic keys, data, and map unit descriptions, this document provides the foundation for supporting applicable land management decisions using the best-available science. Since these maps were produced using imagery and field data that was primarily collected in 2014, the maps can be considered a reflection of the 2014 ground conditions. Land managers should develop a strategy for maintaining their initial investment in the future. Maintenance and future updates will keep the vegetation map current and useful as vegetation disturbances, treatments, or gradual changes occur over time.

References

Breiman, L. 2001. Random Forests. *Machine Learning*, *45*, 5–32.

Brewer, C., B. Schwind, R. Warbington, W. Clerke, P. Krosse, L. Suring, and M. Schanta. 2005. Section 3: Existing Vegetation Mapping Protocol. In: R. Brohman, L. Bryant eds. *Existing Vegetation Classification and Mapping Technical Guide* (Gen. Tech. Rep. WO-67, 305). Washington, DC: U.S. Department of Agriculture, Forest Service, Ecosystem Management Coordination Staff.

Frescino, T. S., P. L. Patterson, E. A. Freeman, and G. G. Moisen. 2012. Using FIESTA, An R-Based Tool for Analysts, to Look at Temporal Trends in Forest Estimates. In R.S. Morin and G.C. Liknes, *Moving From Status to Trends: Forest Inventory and Analysis (FIA) Symposium 2012* (Gen. Tech. Rep. NRS-P-105, pp. 74-78). Baltimore, MD: U.S. Department of Agriculture, Forest Service, Northern Research Station.

Helms, J. A. (Ed.). 1998. *The Dictionary of Forestry*. Bethesda, MD: Society of American Foresters.

Lillesand, T.M. and R.W. Kiefer. 1994. Remote Sensing and Image Interpretation. 3rd edition. John Wiley & Sons, Inc. New York. 750 p.

McNab, W.H., D.T. Cleland, J.A. Freeouf, J.E. Keys, Jr., G.J. Nowacki, and C.A. Carpenter, comps. 2007. Description of ecological subregions: sections of the conterminous United States [CD-ROM]. Gen. Tech. Report WO-76B. Washington, DC: U.S. Department of Agriculture, Forest Service. 80 p.

Mueggler, W. F. 1988. *Aspen community types of the Intermountain Region* (GTR INT-250, 135 p.). Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station.

Nelson, M.L., C.K. Brewer, and S.J. Solem, eds. 2015. Existing vegetation classification, mapping, and inventory technical guide, version 2.0. Gen. Tech. Rep. WO–90. Washington, DC: U.S. Department of Agriculture, Forest Service, Ecosystem Management Coordination Staff. 210 p.

Padgett, W.G., A.P. Youngblood, and A.H. Winward. 1989. Riparian community types classification of Utah. R4-Ecol-89-01. Ogden, UT: U. S. Department of Agriculture, Forest Service, Intermountain Region. 191 p.

Pfister, R.D. 1972. Vegetation and Soils in the Subalpine Forests of Utah. PhD Thesis, Washington State University. Pullman, WA. 98p.

Ruefenacht, B. 2014. *Review of DEM Derivatives for Vegetation Mapping* (RSAC-10078-RPT1, 19 p.). Salt Lake City, UT: U.S. Department of Agriculture, Forest Service, Remote Sensing Applications Center.

Ryherd, S. and C. Woodcock. 1996. Combining Spectral and Texture Data in the Segmentation of Remotely Sensed Images. *Photogrammetric Engineering & Remote Sensing, 62*(2), 181–194.

Stehman, S. V. and R. L. Czaplewski. 1998. Design and Analysis for Thematic Map Accuracy Assessment: Fundamental Principles. *Remote Sensing of Environment. 64*, 331–344.

Story, M. and R. G. Congalton. 1986. Accuracy Assessment: A User's Perspective. *Photogrammetric Engineering and Remote Sensing. 52,* 397–399.

Tart, D., D. Tait, and M. Anderson. 2018. *Fishlake National Forest Draft Existing Vegetation Keys*. U.S. Department of Agriculture, Forest Service, Region 4 Document.

U.S. Department of Agriculture, Forest Service. 2013. *U.S. Department of Agriculture: Forest Service, Inventory, Monitoring, and Assessment Strategy*. Retrieved from https://ems-team.usda.gov/sites/fs-nrm-imac/Background%20Documents/FS%20IMA%20Strategy.pdf.

U.S. Department of Agriculture, Forest Service. 1986. *Fishlake National Forest Land and Resource Management Plan.* Retrieved on February 17, 2017 from https://www.fs.usda.gov/detail/fishlake/landmanagement/planning/?cid=stelprdb5116158.

West, N.E., R.J. Tausch, and P.T. Tueller. 1998. A Management-Oriented Classification of Pinyon-Juniper Woodlands of the Great Basin. RMRS-GTR-12. USDA-FS, Rocky Mountain Research Station. Ogden, UT. 42p.

Youngblood, A.P. and R.L. Mauk. 1985. Coniferous forest habitat types of central and southern Utah. GTR INT-187. USDA Forest Service, Intermountain Forest and Range Exp. Station. Ogden, UT. 89 p.

Appendices

Appendix A: Acquired Geospatial Data for Mapping

Geospatial Data	Source	Use
Landsat 8 OLI – June, July & October 2013	USGS GloVis	Segmentation
Landsat 8 OLI – June & July 2013; June, July, August, September & October 2014	USGS GloVis	Modeling
NAIP 2011 (1-meter)	USDA Farm Service Agency	Modeling & Segmentation
NAIP 2014 (1-meter)	USDA Farm Service Agency	Modeling
Digital Elevation Model (DEM)	i-cubed DataDoors	Modeling
Administrative boundary	Fishlake NF	Identify project area
Land ownership	Fishlake NF	Field site selection
Roads & trails	Fishlake NF	Field site selection
Hydrology	Fishlake NF	Field site selection
FSVeg	Fishlake NF	Field site selection & Map edits
Gap Landcover	USGS Gap Analysis Program	Field site selection & Map edits
National Land Cover Database (NLCD 2011)	Multi-Resolution Land Characteristics (MRLC) Consortium	Field site selection & Map edits
Fire severity & burn perimeters	MTBS	Modeling
Climate – maximum temperature (30yr)	Prism	Modeling
Climate – minimum temperature (30yr)	Prism	Modeling
Climate – precipitation (30yr)	Prism	Modeling
IfSAR	Intermap Technologies	Tree size modeling

Appendix B: Vegetation Indices, Transformations, and Topographic Derivatives

Geospatial Data	Source	Use
Landsat 8 OLI – NDVI	Customized model	Modeling & Segmentation
Landsat 8 OLI – Principal Components (3)	Customized model	Modeling
Landsat 8 OLI – Tasseled Cap	Customized model	Modeling
Landsat 8 OLI – Seasonal Coefficients	Customized model	Modeling
NAIP 2011 – NDVI	Customized model	Modeling & Segmentation
NAIP 2014 – NDVI	Customized model	Modeling
Slope (degrees)	Customized model	Field site selection & Modeling
Aspect	Customized model	Field site selection
Slope-Aspect (Cos)	Customized model	Segmentation & Modeling
Slope-Aspect (Sin)	Customized model	Segmentation & Modeling
Heatload	Customized model	Modeling
Valleybottom	Customized model	Modeling

Appendix C: Existing Vegetation Keys

Fishlake National Forest

DRAFT Existing Vegetation Keys

1/12/2018

Dave Tart, Dave Tait, Marisa Anderson

NOTE: These keys apply only to existing vegetation for mid-level mapping, not potential or historical vegetation.

R4 Key to Vegetation Formations

This key does not apply to lands used for agriculture or urban/residential development. It applies only to natural and semi-natural vegetation dominated by vascular plants. Semi-natural vegetation includes planted vegetation that is not actively managed or cultivated.

All cover values in the key to formations are absolute cover, not relative cover, for the life form. See Appendix A for a discussion of absolute versus relative cover. In this key, tree cover includes both regeneration and overstory sized trees, so that young stands of trees are classified as forest.

First, identify the R4 Vegetation Formation of the plot, stand, or polygon using the key below. Vegetation Type Map Units (Map Unit) and Vegetation Group Map Unit (Veg Group) codes are defined in Appendix B.

			Key or Dominance Type	Map Unit
1a		All vascular plants total < 1% canopy cover……..……..	**Non-Vegetated (p.24)**	
1b		All vascular plants total ≥ 1% canopy cover……………	2	
	2a	All vascular plants total < 10% canopy cover…………	**Sparse Vegetation (SP VEG)**	**BR/SV**
	2b	All vascular plants total ≥ 10% canopy cover…………	3	
3a		Trees total ≥ 10% canopy cover………………………...	4	
3b		Trees total < 10% canopy cover………………………...	5	
	4a	Stand located above continuous forest line and trees stunted (< 5m tall) by harsh alpine growing conditions..	**Shrubland Key (p.11)**	
	4b	Stand not above continuous forest line; trees not stunted…………………………………………………….	**Forest & Woodland Key (p.2)**	
5a		Shrubs total ≥ 10% canopy cover……….………………	**Shrubland Key (p.11)**	
5b		Shrubs total < 10% canopy cover…………………..……	6	
	6a	Herbaceous vascular plants total ≥ 10% canopy cover..	7	
	6b	Herbaceous vascular plants total < 10% canopy cover..	8	
7a		Total cover of graminoids ≥ total cover of forbs……….	**Grassland Key (p.15)**	
7b		Total cover of graminoids < total cover of forbs…….….	**Forbland Key (p.19)**	
	8a	Trees total ≥ 5% canopy cover………………….....…....	**Sparse Tree (SP TREE)**	**BR/SV**
	8b	Trees total < 5% canopy cover……………………..........	9	
9a		Shrubs total ≥ 5% canopy cover………………………..	**Sparse Shrub (SP SHRUB)**	**BR/SV**
9b		Shrubs total < 5% canopy cover………………………....	10	
	10a	Herbaceous vascular plants total ≥ 5% canopy cover...	**Sparse Herbaceous (SP HERB)**	**BR/SV**
	10b	Herbaceous vascular plants total < 5% canopy cover...	**Sparse Vegetation (SP VEG)**	**BR/SV**

Forest and Woodland Key

Dominance Types (d.t.) and DT Phases (d.t.p.)

Instructions:

1. Preferably, plots or polygons should be keyed out based on overstory canopy cover (trees forming the upper or uppermost canopy layer) by tree species.
2. Plots or polygons lacking such data or lacking an overstory layer should be keyed out using total cover by species.
3. If a plot or polygon does not key out using overstory cover, then it may be keyed using total tree cover.
4. If two trees are equally abundant, the species encountered first in the key is recorded as the most abundant.
5. Woodland tree species include Utah juniper, Rocky Mountain juniper, bigtooth maple, curlleaf mountain mahogany, twoneedle pinyon, singleleaf pinyon, and Gambel oak.
6. If a tree species is not listed, then consult with the Regional Ecologist to assign a dominance type and map unit.
7. If Map Unit is ‘n/a’ (not applicable), then a sufficient number of field sites were not available to retain the dominance type as a map unit, and it was considered too ecologically distinct to combine with another map unit. Any available field data for the dominance type were still used for coarser level mapping as appropriate (e.g., conifer vs. other vegetation) and also for describing map unit composition.

			DT or DT Phase Code	Map Unit	Veg Group
1a		Narrowleaf cottonwood is the most abundant tree species………	**POAN3 d.t.**	**RW**	**R**
1b		Narrowleaf cottonwood not the most abundant tree species…….	**2**		
	2a	Fremont cottonwood is the most abundant tree species………...	**POFR2 d.t.**	**RW**	**R**
	2b	Fremont cottonwood is not the most abundant tree species…….	**3**		
3a		Thinleaf alder is the most abundant tree species……………..…..	**ALINT d.t.**	**RW**	**R**
3b		Thinleaf alder is not the most abundant tree species…………..…...	**4**		
	4a	Water birch is the most abundant tree species…………………..…..	**BEOC2 d.t.**	**RW**	**R**
	4b	Water birch is not the most abundant tree species…………….....	**5**		
5a		Velvet ash is the most abundant tree species…………………..….	**FRVE2 d.t.**	**RW**	**R**
5b		Velvet ash is not the most abundant tree species………………...	**6**		
	6a	Boxelder is the most abundant tree species…………………….....	**ACNE2 d.t.**	**RW**	**R**
	6b	Boxelder is not the most abundant tree species………………..….	**7**		
7a		Russian olive is the most abundant tree species………………….	**ELAN d.t**	**RW**	**R**
7b		Russian olive is not the most abundant tree species…………..….	**8**		
	8a	Five-stamen tamarisk is the most abundant species……………...	**TACH2 d.t.**	**RW**	**R**
	8b	Five-stamen tamarisk is not the most abundant species……...….	**9**		
9a		Smallflower tamarisk is the most abundant species………………	**TAPA4 d.t.**	**RW**	**R**
9b		Smallflower tamarisk is not the most abundant species…………..	**10**		
	10a	Saltcedar (tamarisk) is the most abundant species……………….	**TARA d.t.**	**RW**	**R**
	10b	Saltcedar (tamarisk) is not the most abundant species…………..	**11**		
11a		Blue spruce is the most abundant tree species............................	**12**		
11b		Blue spruce is not the most abundant tree species......................	**22**		
	12a	Blue spruce ≥ 75% relative canopy cover.....................................	**PIPU-PIPU d.t.p.**	**SF**	**C**
	12b	Blue spruce < 75% relative cover cover.......................................	**13**		

			DT or DT Phase Code	Map Unit	Veg Group
13a		Narrowleaf cottonwood is the second most abundant tree species; it and blue spruce ≥ 65% relative canopy cover…………	**PIPU-POAN3 d.t.p.**	**RW**	**R**
13b		Narrowleaf cottonwood is not the second most abundant tree species and/or it and blue spruce total < 65% relative canopy cover…………………………………………………………………	**14**		
	14a	Quaking aspen is the second most abundant tree species; it and blue spruce ≥ 65% relative canopy cover....................................	**PIPU-POTR5 d.t.p.**	**AS/C**	**D**
	14b	Quaking aspen is not the second most abundant species and/or it and blue spruce total < 65% relative canopy cover……………..	**15**		
15a		Ponderosa pine is the second most abundant tree species; it and blue spruce ≥ 65% relative canopy cover..............................	**PIPU-PIPO d.t.p.**	**PPmix**	**C**
15b		Ponderosa pine is not the second most abundant species and/or it and blue spruce total < 65% relative canopy cover……………..	**16**		
	16a	Douglas-fir is the second most abundant tree species; it and blue spruce ≥ 65% relative canopy cover....................................	**PIPU-PSME d.t.p.**	**DFmix**	**C**
	16b	Douglas-fir is not the second most abundant tree species and/or it and blue spruce total < 65% relative canopy cover……………..	**17**		
17a		White fir is the second most abundant tree species; it and blue spruce ≥ 65% relative canopy cover...	**PIPU-ABCO d.t.p.**	**WFmix**	**C**
17b		White fir is not the second most abundant tree species and/or it and blue spruce total < 65% relative canopy cover………………..	**18**		
	18a	Engelmann spruce is the second most abundant tree species; it and blue spruce ≥ 65% relative canopy cover..............................	**PIPU-PIEN d.t.p.**	**SF**	**C**
	18b	Engelmann spruce is not the second most abundant species and/or it and blue spruce total < 65% relative canopy cover……..	**19**		
19a		Subalpine fir is the second most abundant tree species; it and blue spruce ≥ 65% relative canopy cover....................................	**PIPU-ABLA d.t.p.**	**SF**	**C**
19b		Subalpine fir is not the second most abundant species and/or it and blue spruce total < 65% relative canopy cover………………..	**20**		
	20a	Another forest species is the second most abundant tree species; it and blue spruce ≥ 65% relative canopy cover…………	**PIPU Mix d.t.p.**	**SF**	**C**
	20b	Another forest species is not the second most abundant tree species……………………………………………………………….	**21**		
21a		A woodland species is the second most abundant tree species; it and blue spruce total ≥ 65% relative canopy cover…………..……	**PIPU-WD d.t.p.**	**N/A**	**C**
21b		A woodland species is not the second most abundant tree species……………………………………………………………….	**PIPU d.t.**	**N/A**	**C**
	22a	Quaking aspen is the most abundant tree species.......................	**23**		
	22b	Quaking aspen is not the most abundant tree species.................	**37**		
23a		Quaking aspen ≥ 75% relative canopy cover………….…………	**POTR5-POTR5 d.t.p.**	**AS**	**D**
23b		Quaking aspen < 75% relative canopy cover………….…………	**24**		
	24a	Ponderosa pine is the second most abundant tree species; it and quaking aspen ≥ 65% relative canopy cover.........................	**POTR5-PIPO d.t.p.**	**AS/C**	**D**
	24b	Ponderosa pine is not the second most abundant tree species and/or it and quaking aspen total < 65% relative canopy cover….	**25**		

			DT or DT Phase Code	Map Unit	Veg Group
25a		Douglas-fir is the second most abundant tree species; it and quaking aspen ≥ 65% relative canopy cover................................	**POTR5-PSME d.t.p.**	**AS/C**	**D**
25b		Douglas-fir is not the second most abundant tree species and/or it and quaking aspen total < 65% relative canopy cover…………	**26**		
	26a	White fir is the second most abundant tree species; it and quaking aspen ≥ 65% relative canopy cover................................	**POTR5-ABCO d.t.p.**	**AS/C**	**D**
	26b	White fir is not the second most abundant tree species and/or it and quaking aspen total < 65% relative canopy cover……………	**27**		
27a		Engelmann spruce is the second most abundant tree species; it and quaking aspen ≥ 65% relative canopy cover………………….	**POTR5-PIEN d.t.p.**	**AS/C**	**D**
27b		Engelmann spruce is not the second most abundant tree species and/or it and quaking aspen total < 65% relative canopy cover……………………………………………………………….	**28**		
	28a	Subalpine fir is the second most abundant tree species; it and quaking aspen ≥ 65% relative canopy cover................................	**POTR5-ABLA d.t.p.**	**AS/C**	**D**
	28b	Subalpine fir is not the second most abundant tree species and/or it and quaking aspen total < 65% relative canopy cover….	**29**		
29a		Blue spruce is the second most abundant tree species; it and quaking aspen ≥ 65% relative canopy cover................................	**POTR5-PIPU d.t.p.**	**AS/C**	**D**
29b		Blue spruce is not the second most abundant tree species and/or it and quaking aspen total < 65% relative canopy cover….	**30**		
	30a	Another forest species is the second most abundant species; it and quaking aspen ≥ 65% relative canopy cover………………….	**POTR5 mix d.t.p.**	**AS/C**	**D**
	30b	Another forest species is not the second most abundant species……………………………………………………………….	**31**		
31a		Curlleaf mountain mahogany is the second most abundant tree species; it and quaking aspen ≥ 65% relative canopy cover……	**POTR5-CELE3 d.t.p.**	**AS**	**D**
31b		Curlleaf mountain mahogany is not the second most abundant tree and/or it and quaking aspen < 65% relative canopy cover….	**32**		
	32a	Rocky Mountain juniper is the second most abundant tree species; it and quaking aspen ≥ 65% relative canopy cover……..	**POTR5-JUSC2 d.t.p.**	**AS/C**	**D**
	32b	Rocky Mountain juniper is not the second most abundant tree and/or it and quaking aspen < 65% relative canopy cover……….	**33**		
33a		Utah Juniper, Twoneedle pinyon and/or singleleaf pinyon species is/are the second most abundant tree species………..….	**POTR5-PJ d.t.p.**	**AS/C**	**D**
33b		Utah Juniper, Twoneedle pinyon and/or singleleaf pinyon species is not the second most abundant tree species………..….	**34**		
	34a	Gambel oak is the second most abundant tree species; it and quaking aspen ≥ 65% relative canopy cover……………………...…..	**POTR5-QUGA d.t.p.**	**AS**	**D**
	34b	Gambel oak is not the second most abundant tree and/or it and quaking aspen < 65% relative canopy cover……………………….	**35**		
35a		Bigtooth maple is the second most abundant tree species; it and quaking aspen ≥ 65% relative canopy cover……………………...…..	**POTR5-ACGR3 d.t.p.**	**AS**	**D**
35b		Bigtooth maple is not the second most abundant tree and/or it and quaking aspen < 65% relative canopy cover…………………	**36**		

			DT or DT Phase Code	Map Unit	Veg Group
	36a	Another woodland species is the second most abundant tree species; it and quaking aspen total ≥ 65% relative canopy cover……………………………………………………………..........	POTR5 d.t.	AS	D
	36b	A woodland species is not the second most abundant tree species………………………………………………………………	POTR5 d.t.	AS	D
37a		Great Basin bristlecone pine is the most abundant tree species...	PILO d.t.	BC/LM	C
37b		Great Basin bristlecone pine is not the most abundant tree species………………………………………………………………	38		
	38a	Limber pine is the most abundant tree species……………………	PIFL2 d.t.	BC/LM	C
	38b	Limber pine is not the most abundant tree species……………..…	39		
39a		Ponderosa Pine is the most abundant tree species.....................	40		
39b		Ponderosa Pine is not the most abundant tree species...............	49		
	40a	Ponderosa Pine ≥ 75% relative canopy cover..............................	PIPO-PIPO d.t.p.	PPmix	C
	40b	Ponderosa Pine < 75% relative canopy cover..............................	41		
41a		Quaking aspen is the second most abundant tree species; it and Ponderosa Pine ≥ 65% relative canopy cover..............................	PIPO-POTR5 d.t.p.	AS/C	D
41b		Quaking aspen is not the second most abundant tree species and/or it and ponderosa pine total < 65% relative canopy cover...	42		
	42a	Douglas-fir is the second most abundant tree species; it and ponderosa Pine ≥ 65% relative canopy cover..............................	PIPO-PSME d.t.p.	PPmix	C
	42b	Douglas-fir is not the second most abundant tree species and/or it and ponderosa pine total < 65% relative canopy cover…………	43		
43a		White fir is the second most abundant tree species; it and ponderosa pine ≥ 65% relative canopy cover..............................	PIPO-ABCO d.t.p.	PPmix	C
43b		White fir is not the second most abundant tree species and/or it and ponderosa pine total < 65% relative canopy cover…….…….	44		
	44a	Another forest species is the second most abundant species; it and ponderosa pine ≥ 65% relative canopy cover…………………	PIPO mix d.t.p.	PPmix	C
	44b	Another forest species is not the second most abundant species.	45		
45a		Rocky Mountain juniper is the second most abundant tree species; it and ponderosa pine total ≥ 65% relative canopy cover…………………………………………………………………….	PIPO-JUSC2 d.t.p.	PPmix	C
45b		Rocky Mountain juniper is not the second most abundant tree species and/or it and ponderosa pine total < 65% relative canopy cover...	46		
	46a	Gambel oak is the second most abundant tree species; it and ponderosa pine total ≥ 65% relative canopy cover…………………………………………………………………….	PIPO-QUGA d.t.p.	PPmix	C
	46b	Gambel oak is not the second most abundant tree species and/or it and ponderosa pine total < 65% relative canopy cover...	47		

			DT or DT Phase Code	Map Unit	Veg Group
47a		Curlleaf mountain mahogany is the second most abundant tree species; it and ponderosa pine total ≥ 65% relative canopy cover………………………………………………………………	PIPO-CELE3 d.t.p.	PPmix	C
47b		Curlleaf mountain mahogany is not the second most abundant tree species and/or it and ponderosa pine total < 65% relative canopy cover...	48		
	48a	Another woodland species is the second most abundant tree species; it and ponderosa pine total ≥ 65% relative canopy cover………..………………………………………….…………..…	PIPO-WD mix d.t.p.	PPmix	C
	48b	A woodland tree species is not the second most abundant species…………………………………………………….........…..	PIPO d.t.	PPmix	C
49a		Douglas-fir is the most abundant tree species..............................	50		
49b		Douglas-fir is not the most abundant tree species........................	59		
	50a	Douglas-fir ≥ 75% relative canopy cover……….……...................	PSME-PSME d.t.p.	DFmix	C
	50b	Douglas-fir < 75% relative cover cover………………...................	51		
51a		Quaking aspen is the second most abundant tree species; it and Douglas-fir ≥ 65% relative canopy cover……………...................	PSME-POTR5 d.t.p.	AS/C	D
51b		Quaking aspen is not the second most abundant tree species and/or it and Douglas-fir total < 65% relative canopy cover………	52		
	52a	Ponderosa pine is the second most abundant tree species; it and Douglas-fir ≥ 65% relative canopy cover...............................	PSME-PIPO d.t.p.	DFmix	C
	52b	Ponderosa pine is not the second most abundant tree species and/or it and Douglas-fir total < 65% relative canopy cover…….	53		
53a		White fir is the second most abundant tree species; it and Douglas-fir ≥ 65% relative canopy cover......................................	PSME-ABCO d.t.p.	DFmix	C
53b		White fir is not the second most abundant tree species and/or it and Douglas-fir total < 65% relative canopy cover………………..	54		
	54a	Blue spruce is the second most abundant tree species; it and Douglas-fir ≥ 65% relative canopy cover......................................	PSME-PIPU d.t.p.	DFmix	C
	54b	Blue spruce is not the second most abundant tree species and/or it and Douglas-fir total < 65% relative canopy cover……..	55		
55a		Engelmann spruce is the second most abundant tree species; it and Douglas-fir ≥ 65% relative canopy cover...............................	PSME-PIEN d.t.p.	DFmix	C
55b		Engelmann spruce is not the second most abundant tree species and/or it and Douglas-fir total < 65% relative canopy cover…………………………………………………………………	56		
	56a	Subalpine fir is the second most abundant tree species; it and Douglas-fir ≥ 65% relative canopy cover......................................	PSME-ABLA d.t.p.	DFmix	C
	56b	Subalpine fir is not the second most abundant tree species and/or it and Douglas-fir total < 65% relative canopy cover……..	57		
57a		Another forest species is the second most abundant species; it and Douglas-fir ≥ 65% relative canopy cover……………………..…..	PSME mix d.t.p.	DFmix	C
57b		Another forest species is not the second most abundant species.	58		

			DT or DT Phase Code	Map Unit	Veg Group
	58a	A woodland species is the second most abundant tree species; it and Douglas-fir total ≥ 65% relative canopy cover………………	**PSME-WD mix d.t.p.**	**DFmix**	**C**
	58b	A woodland species is not the second most abundant tree species……………………………………………………………..….....	**PSME d.t.**	**DFmix**	**C**
59a		Engelmann spruce is the most abundant tree species.................	**60**		
59b		Engelmann spruce is not the most abundant tree species...........	**68**		
	60a	Engelmann spruce ≥ 75% relative canopy cover……………..........	**PIEN-PIEN d.t.p.**	**SF**	**C**
	60b	Engelmann spruce < 75% relative canopy cover............................	**61**		
61a		Quaking aspen is the second most abundant tree species; it and Engelmann spruce ≥ 65% relative canopy cover..........................	**PIEN-POTR5 d.t.p.**	**AS/C**	**D**
61b		Quaking aspen is not the second most abundant tree species and/or it and Engelmann spruce total < 65% relative canopy cover…………………………………………………………………	**62**		
	62a	Douglas-fir is the second most abundant tree species; it and Engelmann spruce ≥ 65% relative canopy cover..........................	**PIEN-PSME d.t.p.**	**SF**	**C**
	62b	Douglas-fir is not the second most abundant tree species and/or it and white fir total < 65% relative canopy cover………………..…..	**63**		
63a		White fir is the second most abundant tree species; it and Engelmann spruce ≥ 65% relative canopy cover……...................	**PIEN-ABCO d.t.p.**	**SF**	**C**
63b		White fir is not the second most abundant tree species and/or it and Engelmann spruce total < 65% relative canopy cover………	**64**		
	64a	Subalpine fir is the second most abundant tree species; it and Engelmann spruce ≥ 65% relative canopy cover..........................	**PIEN-ABLA d.t.p.**	**SF**	**C**
	64b	Subalpine fir is not the second most abundant tree species and/or it and Engelmann spruce total < 65% relative canopy cover……………………………………………………………….…	**65**		
65a		Blue spruce is the second most abundant tree species; it and Engelmann spruce ≥ 65% relative canopy cover………………….....	**PIEN-PIPU d.t.p.**	**SF**	**C**
65b		Blue spruce is not the second most abundant tree species and/or it and Engelmann spruce total < 65% relative canopy cover…………………………………………………………………	**66**		
	66a	Another forest species is the second most abundant tree species; it and Engelmann spruce ≥ 65% relative canopy cover………………………………………...………...………….....	**PIEN mix d.t.p.**	**SF**	**C**
	66b	Another forest species is not the second most abundant tree species………………………………………………………....	**67**		
67a		A woodland species is the second most abundant tree species; it and Engelmann spruce total ≥ 65% relative canopy cover……….	**PIEN-WD d.t.p.**	**SF**	**C**
67b		A woodland species is not the second most abundant tree species…………………………………………………………………	**PIEN d.t.**	**SF**	**C**
	68a	White fir is the most abundant tree species.................................	**69**		
	68b	White fir is not the most abundant tree species...........................	**79**		
69a		White fir ≥ 75% relative canopy cover...	**ABCO-ABCO d.t.p.**	**WF**	**C**
69b		White fir < 75% relative cover cover...	**70**		

			DT or DT Phase Code	Map Unit	Veg Group
	70a	Quaking aspen is the second most abundant tree species; it and white fir ≥ 65% relative canopy cover...	**ABCO-POTR5 d.t.p.**	**AS/C**	**D**
	70b	Quaking aspen is not the second most abundant tree species and/or it and white fir total < 65% relative canopy cover…………	**71**		
71a		Ponderosa pine is the second most abundant tree species; it and white fir ≥ 65% relative canopy cover....................................	**ABCO-PIPO d.t.p.**	**WFmix**	**C**
71b		Ponderosa pine is not the second most abundant tree species and/or it and white fir total < 65% relative canopy cover………...	**72**		
	72a	Bristlecone pine is the second most abundant tree species; it and white fir ≥ 65% relative canopy cover....................................	**ABCO-PILO d.t.p.**	**WFmix**	**C**
	72b	Bristlecone pine is not the second most abundant tree species and/or it and white fir total < 65% relative canopy cover……………...	**73**		
73a		Douglas-fir is the second most abundant tree species; it and white fir ≥ 65% relative canopy cover...	**ABCO-PSME d.t.p.**	**WFmix**	**C**
73b		Douglas-fir is not the second most abundant tree species and/or it and Douglas-fir total < 65% relative canopy cover……………...	**74**		
	74a	Blue spruce is the second most abundant tree species; it and white fir ≥ 65% relative canopy cover...	**ABCO-PIPU d.t.p.**	**WFmix**	**C**
	74b	Blue spruce is not the second most abundant tree species and/or it and white fir total < 65% relative canopy cover……….....	**75**		
75a		Engelmann spruce is the second most abundant tree species; it and white fir ≥ 65% relative canopy cover....................................	**ABCO-PIEN d.t.p.**	**WFmix**	**C**
75b		Engelmann spruce is not the second most abundant tree species and/or it and white fir total < 65% relative canopy cover…………………..…………………………………….….....	**76**		
	76a	Subalpine fir is the second most abundant tree species; it and white fir ≥ 65% relative canopy cover...	**ABCO-ABLA d.t.p.**	**WFmix**	**C**
	76b	Subalpine fir is not the second most abundant tree species and/or it and white fir total < 65% relative canopy cover……….....	**77**		
77a		Another forest species is the second most abundant tree species; it and white fir ≥ 65% relative canopy cover……………..…	**ABCO Mix d.t.p.**	**WFmix**	**C**
77b		Another forest species is not the second most abundant tree species…...	**78**		
	78a	A woodland species is the second most abundant tree species; it and white fir total ≥ 65% relative canopy cover…………………….	**ABCO -WD d.t.p.**	**WFmix**	**C**
	78b	A woodland species is not the second most abundant tree species…………………………………………………..…….....	**ABCO d.t.**	**WFmix**	**C**
79a		Subalpine is the most abundant tree species...............................	**80**		
79b		Subalpine fir is not the most abundant tree species………............	**88**		
	80a	Subalpine fir ≥ 75% relative canopy cover....................................	**ABLA-ABLA d.t.p.**	**SF**	**C**
	80b	Subalpine fir < 75% relative cover cover......................................	**81**		

			DT or DT Phase Code	Map Unit	Veg Group
81a		Quaking aspen is the second most abundant tree species; it and Subalpine fir ≥ 65% relative canopy cover....................................	**ABLA-POTR5 d.t.p.**	**AS/C**	**D**
81b		Quaking aspen is not the second most abundant tree species and/or it and subalpine fir total < 65% relative canopy cover…….	**82**		
	82a	Douglas-fir is the second most abundant tree species; it and subalpine fir ≥ 65% relative canopy cover……………………..…..….	**ABLA-PSME d.t.p.**	**SF**	**C**
	82b	Douglas-fir is not the second most abundant tree species and/or it and subalpine fir total < 65% relative canopy cover……………..	**83**		
83a		White fir is the second most abundant tree species; it and subalpine fir ≥ 65% relative canopy cover....................................	**ABLA-ABCO d.t.p.**	**SF**	**C**
83b		White fir is not the second most abundant tree species and/or it and subalpine fir total < 65% relative canopy cover…………..…..	**84**		
	84a	Engelmann spruce is the second most abundant tree species; it and subalpine fir ≥ 65% relative canopy cover………………….....	**ABLA-PIEN d.t.p.**	**SF**	**C**
	84b	Engelmann spruce is not the second most abundant tree species and/or it and subalpine fir total < 65% relative canopy cover……………………………………………………….……...……	**85**		
85a		Blue spruce is the second most abundant tree species; it and subalpine fir ≥ 65% relative canopy cover……………………...........	**ABLA-PIPU d.t.p.**	**SF**	**C**
85b		Blue spruce is not the second most abundant tree species and/or it and subalpine fir total < 65% relative canopy cover…….	**86**		
	86a	Another forest species is the second most abundant tree species; it and subalpine fir ≥ 65% relative canopy cover……......	**ABLA mix d.t.p.**	**SF**	**C**
	86b	Another forest species is not the second most abundant tree species…………………………………………………………..…..	**87**		
87a		A woodland species is the second most abundant tree species; it and Subalpine fir total ≥ 65% relative canopy cover……..…...	**ABLA-WD d.t.p.**	**SF**	**C**
87b		A woodland species is not the second most abundant tree species……………………………………………………………….….	**ABLA d.t.**	**SF**	**C**
	88a	Curlleaf mountain mahogany is the most abundant tree species..	**CELE3 d.t.**	**MM**	**W**
	88b	Curlleaf mountain mahogany is not the most abundant tree species…………………………………………………………………	**89**		
89a		Rocky Mountain juniper is the most abundant tree species………	**90**		
89b		Rocky Mountain juniper is not the most abundant tree species…	**95**		
	90a	Rocky mountain juniper ≥ 75% relative canopy cover..................	**JUSC2-JUSC2 d.t.p.**	**RMJmix**	**W**
	90b	Rocky mountain juniper < 75% relative cover cover……………...	**91**		
91a		Ponderosa pine is the second most abundant tree species; it and Rocky Mountain juniper ≥ 65% relative canopy cover…….....	**JUSC2-PIPO d.t.p.**	**PPmix**	**C**
91b		Ponderosa pine is not the second most abundant tree species and/or it and Rocky Mountain juniper total < 65% relative canopy cover…………………………………………………………….………	**92**		

			DT or DT Phase Code	Map Unit	Veg Group
	92a	Another forest species is the second most abundant tree species; it and Rocky Mountain juniper ≥ 65% relative canopy cover………………………………………………………...………	**JUSC2 mix d.t.p.**	**RMJmix**	**W**
	92b	Another forest species is not the second most abundant tree species………………………………….…………………………	**93**		
93a		Utah Juniper, Twoneedle pinyon and/or singleleaf pinyon species is/are the second most abundant tree species………...…	**JUSC2-PJ d.t.p.**	**RMJmix**	**W**
93b		Utah Juniper, Twoneedle pinyon and/or singleleaf pinyon species is not the second most abundant tree species………..…	**94**		
	94a	Another woodland species is the second most abundant tree species…………………………………………………………….…	**JUSC2-WD d.t.p.**	**RMJmix**	**W**
	94b	A woodland species is not the second most abundant tree species…………………………………………………………..……	**JUSC2 d.t.**	**RMJmix**	**W**
95a		Utah juniper is the most abundant tree species….........................	**JUOS d.t.**	**PJ**	**W**
95b		Utah juniper is not the most abundant tree species…………….	**96**		
	96a	Twoneedle pinyon is the most abundant tree species…………..……	**PIED d.t.**	**PJ**	**W**
	96b	Twoneedle pinyon is not the most abundant tree species………..	**97**		
97a		Singleleaf pinyon is the most abundant tree species……………...	**PIMO d.t.**	**PJ**	**W**
97b		Singleleaf pinyon is not the most abundant tree species………...	**98**		
	98a	Gambel oak is the most abundant tree species ………………...	**QUGA d.t.**	**GO**	**W**
	98b	Gambel oak is not the most abundant tree species………………	**99**		
99a		Bigtooth Maple is the most abundant tree species……………..…...	**ACGR3**	***TBD**	**W, R, or D**
99b		Bigtooth Maple is not the most abundant tree species…………...	**Undefined**	**UND**	

***TBD (To Be Determined):** Assigned by field personnel on site. Choose the Vegetation Type Map Unit assigned to the next most dominant Forest/Woodland tree species present on the site. Bigtooth Maple could potentially be within the Riparian Vegetation Group Map or the Woodland; it is not a common dominate type within the mapping area.

Shrubland Key

Dominance Types

Instructions:

Plots or polygons should be keyed out based on total cover by species. This key is divided into riparian, alpine, and upland sections. **First, identify the physical setting of the plot, stand, or polygon using the key below.**

For the purposes of this key, a riparian setting is defined as an area (typically transitional between aquatic and terrestrial ecosystems) identified by soil characteristics associated with at least seasonally high water tables, distinctive vegetation that requires or tolerates free or unbound water (Manning and Padgett 1995), proximity to a stream or lake, and/or topographic position (e.g., valley bottom). The alpine setting includes the area above the upper limit of continuous forest. Above this limit trees occur only in scattered patches and become increasingly stunted at higher elevations (Arno and Hammerly 1984). In this key, the alpine setting takes precedence over the riparian setting. The upland setting includes non-riparian areas below the continuous forest line.

It is likely that some dominance types occur in more than one of these settings. If your plot does not key out successfully in one setting, then try another setting. For example, gooseberry currant is in the upland shrubland key but also is found in the alpine and riparian shrubland keys.

Key to Physical Habitat Setting

Key Leads:

1a	Stand is located in an alpine setting above the upper elevation limit of continuous forest………………………………………………………………………	**Go to Alpine Key (p.11)**
1b	Stand is located below the upper elevation limit of continuous forest……………	**2**
2a	Stand is located in a riparian setting as indicated by proximity to a stream or lake, topographic position, plant species that require or tolerate free or unbound water, and/or soil properties associated with seasonally high water tables………………………………………………………………………………	**Go to Riparian Key (p.12)**
2b	Stand not located in a riparian setting as described above………………………..	**Go to Upland Key (p.13)**

Key to Alpine Shrubland Dominance Types

Instructions:

1. Plots or polygons should be keyed out based on total cover by species.
2. Codes for dominance type and vegetation type map unit can be found using Table 1. Find the name of the most abundant shrub in column 1 and move to column 2 for the dominance type code, column 3 for the vegetation type map unit code, and column 4 for the vegetation map group code.
3. When two or more shrub species are equal in abundance, the species listed with the lowest rank number in Table 1 column 5 is used to assign the dominance type and vegetation type map unit.
4. If the most abundant shrub species is not listed in Table 2, then consult with the Regional Ecologist to assign a dominance type.

Table 1. Most Abundant Alpine Shrub and Indicated Dominance Type and Veg. Type Map Unit.

(1) Most Abundant Shrub (Dominance Type)		(2) Dom. Type Code	(3) Veg Type Map Unit	(4) Veg Group	(5) Rank
Abies lasiocarpa krummholz	subalpine fir	ABLA-K	**ALP**	**A**	2
Artemisia frigida	fringed sagebrush	ARFR4-A	**ALP**	**A**	4
Picea engelmannii krummholz	Engelmann spruce	PIEN-K	**ALP**	**A**	1
Ribes montigenum	gooseberry currant	RIMO2-A	**ALP**	**A**	3
Species not listed above		See Instruction 3 above	**ALP**	**A**	
Species unidentifiable		UNKNOWN	**ALP**	**A**	

Key to Riparian Shrubland Dominance Types

Instructions:

1. Plots or polygons should be keyed out based on total cover by species.
2. Codes for dominance type and vegetation type map unit can be found using Table 2. Find the name of the most abundant shrub in column 1 and move to column 2 for the dominance type code, column 3 for the vegetation type map unit code, and column 4 for the vegetation map group code.
3. When two or more shrub species are equal in abundance, the species listed with the lowest rank number in Table 2 column 5 is used to assign the dominance type and vegetation type map unit.
4. If the most abundant shrub species is not listed in Table 2, then consult with the Regional Ecologist to assign a dominance type.

Table 2. Most Abundant Riparian Shrub and Indicated Dominance Type and Veg. Type Map Unit.

(1) Most Abundant Shrub (Dominance Type)		(2) Dom. Type Code	(3) Veg Type Map Unit	(4) Veg Group	(5) Rank
Alnus incana ssp. *tenuifolia*	thinleaf alder	ALINT	RW	**R**	28
Artemisia cana ssp. *viscidula*	silver sagebrush	ARCAV2-R	RW	**R**	21
Betula occidentalis	water birch	BEOC2	RW	**R**	30
Cornus sericea	redosier dogwood	COSE16	RW	**R**	15
Dasiphora fruticosa	shrubby cinquefoil	DAFR6-R	RW	**R**	19
Lonicera involucrata	twinberry honeysuckle	LOIN5	RW	**R**	23
Prunus virginiana	chokecherry	PRVI-R	RW	**R**	26
Rhus glabra	smooth sumac	RHGL-R	RW	**R**	22
Rhus trilobata	skunkbush sumac	RHTR-R	RW	**R**	17
Ribes aureum	golden currant	RIAU	RW	**R**	18
Ribes inerme	whitestem gooseberry	RIIN2	RW	**R**	14
Ribes montigenum	gooseberry currant	RIMO2-R	RW	**R**	20
Rosa woodsii	Woods' rose	ROWO-R	RW	**R**	16
Rubus idaeus	American red raspberry	RUID-R	RW	**R**	27
Salix arizonica	Arizona willow	SAAR14	RW	**R**	10
Salix bebbiana	Bebb willow	SABE2	RW	**R**	7
Salix boothii	Booth's willow	SABO2	RW	**R**	2
Salix drummondiana	Drummond's willow	SADR	RW	**R**	3
Salix exigua	narrowleaf willow	SAEX	RW	**R**	5
Salix geyeriana	Geyer's willow	SAGE2	RW	**R**	4
Salix glauca	grayleaf willow	SAGL	RW	**R**	11
Salix lucida ssp. *lasiandra*	Pacific willow	SALUL	RW	**R**	6
Salix lutea	yellow willow	SALU2	RW	**R**	9
Salix petrophila	alpine willow	SAPE18	RW	**R**	12
Salix planifolia	diamondleaf willow	SAPL2	RW	**R**	8
Salix scouleriana	Scouler's willow	SASC-R	RW	**R**	13
Salix wolfii	Wolf's willow	SAWO	RW	**R**	1
Sambucus nigra ssp. *cerulea*	blue elderberry	SANIC5-R	RW	**R**	24
Sambucus racemosa	red elderberry	SARA2-R	RW	**R**	25
Tamarix chinensis	fivestamen tamarisk	TACH2	RW	**R**	31
Tamarix parviflora	smallflower tamarisk	TAPA4	RW	**R**	32
Tamarix ramosissima	saltcedar	TARA	RW	**R**	29
Species not listed above		See Instruction 4 above	RW	**R**	
Species unidentifiable		UNKNOWN	RW	**R**	

Key to Upland Shrubland Dominance Types

Instructions:

1. Plots or polygons should be keyed out based on total cover by species.
2. Codes for dominance type and vegetation type map unit can be found using Table 3. Find the name of the most abundant shrub in column 1 and move to column 2 for the dominance type code, column 3 for the vegetation type map unit code, and column 4 for the vegetation map group code.
3. When two or more shrub species are equal in abundance, the species listed with the lowest rank number in Table 3 column 5 is used to assign the dominance type and vegetation type map unit.
4. If the most abundant shrub species is not listed in Table 3, then consult with the Regional Ecologist to assign a dominance type and map unit.
5. If Map Unit is 'n/a' (not applicable), then a sufficient number of field sites were not available to retain the dominance type as a map unit, and it was considered too ecologically distinct to combine with another map unit. Any available field data for the dominance type were still used for coarser level mapping as appropriate (e.g., shrub vs. other vegetation) and also for describing map unit composition.

Table 3. Most Abundant Upland Shrub and Indicated Dominance Type and Veg. Type Map Unit.

(1) Most Abundant Shrub (Dominance Type)		(2) Dom. Type Code	(3) Veg Type Map Unit	(4) Veg Group	(5) Rank
Amelanchier alnifolia	Saskatoon serviceberry	AMAL2	**MS**	**S**	15
Amelanchier utahensis	Utah serviceberry	AMUT	**MS**	**S**	18
Arctostaphylos patula	greenleaf manzanita	ARPA6	***TBD**	**S**	
Arctostaphylos pungens	pointleaf manzanita	ARPU5	***TBD**	**S**	
Artemisia cana ssp. *viscidula*	mountain silver sagebrush	ARCAV2-U	**SSB**	**S**	1
Artemisia filifolia	sand sagebrush	ARFI2	**N/A**	**S**	
Artemisia frigida	fringed sagebrush	ARFR4-U	***TBD**	**S**	
Artemisia nova	black sagebrush	ARNO4	**BLSB**	**S**	29
Artemisia pygmaea	pygmy sagebrush	ARPY2	**BLSB**	**S**	30
Artemisia spiciformis	Snowfield sagebrush	ARSP8	**SSB**	**S**	2
Artemisia tridentata ssp. *tridentata*	basin big sagebrush	ARTRT	**WSB/BSB**	**S**	28
Artemisia tridentata ssp. *vaseyana*	mountain big sagebrush	ARTRV	**MSB**	**S**	26
Artemisia tridentata ssp. *wyomingensis*	Wyoming big sagebrush	ARTRW8	**WSB/BSB**	**S**	27
Atriplex canescens	fourwing saltbush	ATCA2	**N/A**	**S**	
Atriplex confertifolia	shadscale saltbush	ATCO	**N/A**	**S**	
Atriplex corrugata	Mat saltbush	ATCO4	**N/A**	**S**	
Atriplex cuneate	Valley saltbush	ATCU	**N/A**	**S**	
Ceanothus fendleri	Fendler's ceanothus	CEFE	***TBD**	**S**	
Ceanothus greggii	desert ceanothus	CEGR	***TBD**	**S**	
Ceanothus martinii	Martin's ceanothus	CEMA2	***TBD**	**S**	
Cercocarpus intricatus	littleleaf mountain mahogany	CEIN7	***TBD**	**S**	
Cercocarpus montanus	alderleaf mountain mahogany	CEMO2	***TBD**	**S**	
Chrysothamnus depressus	longflower rabbitbrush	CHDE2	**MS**	**S**	25
Chrysothamnus greenei	Greene's rabbitbrush	CHGR6	**BLSB**	**S**	31
Chrysothamnus vaseyi	Vasey's rabbitbrush	CHVA2	***TBD**	**S**	
Chrysothamnus viscidiflorus	yellow rabbitbrush	CHVI8	***TBD**	**S**	
Coleogyne ramosissima	blackbrush	CORA	**N/A**	**S**	
Dasiphora fruticosa	shrubby cinquefoil	DAFR6-U	**MS**	**S**	3
Ephedra nevadensis	Nevada jointfir	EPNE	**N/A**	**S**	
Ephedra torreyana	Torrey's jointfir	EPTO	**N/A**	**S**	
Ephedra viridis	mormon tea	EPVI	**N/A**	**S**	
Ericameria nauseosa	rubber rabbitbrush	ERNA10	***TBD**	**S**	
Ericameria parryi	Parry's rabbitbrush	ERPA30	***TBD**	**S**	
Eriogonum microthecum	slender buckwheat	ERMI4	***TBD**	**S**	

(1) Most Abundant Shrub (Dominance Type)		(2) Dom. Type Code	(3) Veg Type Map Unit	(4) Veg Group	(5) Rank
Glossopetalon spinescens	spiny greasebush	GLSP	**N/A**	**S**	
Gutierrezia sarothrae	broom snakeweed	GUSA2	***TBD**	**S**	
Holodiscus dumosus	rockspirea	HODU	**MS**	**S**	14
Juniperus communis	common juniper	JUCO6	**MS**	**S**	13
Krascheninnikovia lanata	winterfat	KRLA2	***TBD**	**S**	
Mahonia fremontii	Fremont's mahonia	MAFR3	***TBD**	**S**	
Mahonia repens	creeping barberry	MARE11	**MS**	**S**	17
Peraphyllum ramosissimum	wild crab apple	PERA4	***TBD**	**S**	
Prunus virginiana	chokecherry	PRVI-U	**MS**	**S**	16
Purshia mexicana	Mexican cliffrose	PUME	**MS**	**S**	19
Purshia tridentata	antelope bitterbrush	PUTR2	**MS**	**S**	23
Quercus turbinella	Sonoran scrub oak	QUTU2	***TBD**	**S**	
Quercus X pauciloba	few-lobe oak	QUPA4	**MS**	**S**	24
Rhus glabra	smooth sumac	RHGL-U	**MS**	**S**	22
Rhus trilobata	skunkbush sumac	RHTR-U	**MS**	**S**	9
Ribes cereum	wax currant	RICE	**MS**	**S**	21
Ribes montigenum	gooseberry currant	RIMO2-U	**MS**	**S**	7
Ribes viscosissimum	sticky currant	RIVI3	**MS**	**S**	8
Rosa woodsii	Woods' rose	ROWO-U	**MS**	**S**	10
Rubus idaeus	American red raspberry	RUID-U	**MS**	**S**	11
Salix scouleriana	Scouler's willow	SASC-U	**MS**	**S**	6
Sambucus nigra ssp. *cerulea*	blue elderberry	SANIC5-U	**MS**	**S**	5
Sambucus racemosa	red elderberry	SARA2-U	**MS**	**S**	4
Sarcobatus vermiculatus	greasewood	SAVE4	**N/A**	**S**	
Shepherdia rotundifolia	roundleaf buffaloberry	SHRO	**MS**	**S**	12
Symphoricarpos oreophilus	mountain snowberry	SYOR2	**MS**	**S**	20
Tetradymia canescens	spineless horsebrush	TECA2	***TBD**	**S**	
Yucca angustissima	narrowleaf yucca	YUAN2	**N/A**	**S**	
Yucca baccata	banana yucca	YUBA	**N/A**	**S**	
Species not listed above		See Instruction 4 above		**S**	
Species unidentifiable		UNKNOWN		**S**	

***TBD (To Be Determined)**: Assigned by field personnel on site. Choose the Upland Shrubland Vegetation Type Map Unit assigned to the next most dominant type (not assigned as TBD) present on the site.

Instructions:

Plots or polygons should be keyed out based on total cover by species. This key is divided into riparian and alpine/upland sections. First, identify the physical setting of the plot, stand, or polygon using the key below.

For the purposes of this key, a riparian setting is defined as an area (typically transitional between aquatic and terrestrial ecosystems) identified by soil characteristics associated with at least seasonally high water tables, distinctive vegetation that requires or tolerates free or unbound water (Manning and Padgett 1995), proximity to a stream or lake, and/or topographic position (e.g. valley bottom). The alpine setting includes the area above the upper limit of continuous forest. Above this limit trees occur only in scattered patches and become increasingly stunted at higher elevations (Arno and Hammerly 1984). In this key, the alpine setting takes precedence over the riparian setting. The upland setting includes non-riparian areas below the continuous forest line.

It is likely that some dominance types occur in more than one of these settings. If your plot does not key out successfully in one setting, then try another setting. For example, tufted hairgrass is in the riparian herbland key but also is found in the alpine and riparian herbland keys.

Key to Physical Habitat Setting

Key Leads:

1a	Stand is located in an alpine setting above the upper elevation limit of continuous forest…………………………………………………………………………………………	**Go to Alpine & Upland Key (p.17)**
1b	Stand is located below the upper elevation limit of continuous forest…………………...	**2**
2a	Stand is located in a riparian setting as indicated by proximity to a stream or lake, topographic position, plant species that require or tolerate free or unbound water, and/or soil properties associated with seasonally high water tables……………………………………………………………………………….	**Go to Riparian Key (p.16)**
2b	Stand not located in a riparian setting as described above……………………….	**Go to Alpine & Upland Key (p.17)**

Key to Riparian Grassland Dominance Types

Instructions:

1. Codes for dominance type and vegetation type map unit can be found using Table 4. Find the name of the most abundant graminoid in column 1 and move to column 2 for the dominance type code, column 3 for the vegetation type map unit code, and column 4 for the vegetation map group code.
2. When two or more graminoid species are equal in abundance, the species listed with the lowest rank number in Table 4 column 5 is used to assign the dominance type and vegetation type map unit.
3. If the most abundant graminoid species is not listed in Table 4, then consult with the Regional Ecologist to assign a dominance type and map unit.

Table 4. Most Abundant Riparian Graminoid and Indicated Dominance Type and Veg. Type Map Unit.

(1) Most Abundant Graminoid (Dominance Type)		(2) Dom. Type Code	(3) Veg Type Map Unit	(4) Veg Group	(5) Rank
Agrostis stolonifera	creeping bentgrass	AGST2	**RHE**	**R**	19
Agrostis variablis	mountain bentgrass	AGVA-R	**RHE**	**R**	20
Bromus inermis	Smooth brome	BRIN2-R	**RHE**	**R**	26
Carex aquatilis	water sedge	CAAQ	**RHE**	**R**	5
Carex douglasii	Douglas' sedge	CADO2	**RHE**	**R**	18
Carex haydeniana	cloud sedge	CAHA6-R	**RHE**	**R**	11
Carex microptera	smallwing sedge	CAMI7-R	**RHE**	**R**	9
Carex nebrascensis	Nebraska sedge	CANE2	**RHE**	**R**	7
Carex pellita	woolly sedge	CAPE42	**RHE**	**R**	13
Carex praegracilis	clustered field sedge	CAPR5-R	**RHE**	**R**	10
Carex utriculata	NW Territory sedge	CAUT	**RHE**	**R**	1
Deschampsia cespitosa	tufted hairgrass	DECE-R	**RHE**	**R**	8
Distichlis spicata	inland saltgrass	DISP	**RHE**	**R**	14
Eleocharis acicularis	needle spikerush	ELAC	**RHE**	**R**	2
Eleocharis palustris	common spikerush	ELPA3	**RHE**	**R**	3
Eleocharis parishii	Parish's spikerush	ELPA4	**RHE**	**R**	4
Glyceria striata	fowl mannagrass	GLST	**RHE**	**R**	12
Juncus arcticus ssp. *litoralis*	mountain rush (baltic)	JUAR2-R	**RHE**	**R**	21
Juncus drummondii	Drummond's rush	JUDR-R	**RHE**	**R**	23
Juncus longistylis	longstyle rush	JULO	**RHE**	**R**	22
Juncus nevadensis	Sierra rush	JUNE	**RHE**	**R**	24
Muhlenbergia asperifolia	scratchgrass	MUAS	**RHE**	**R**	15
Phalaris arundinacea	reed canarygrass	PHAR3	**RHE**	**R**	16
Phragmites australis	common reed	PHAU7	**RHE**	**R**	17
Poa pratensis	Kentucky bluegrass	POPR-R	**RHE**	**R**	25
Schedonorus pratensis	meadow fescue	SCPR4	**RHE**	**R**	6
Species not listed above		See Instruction 3 above	**RHE**	**R**	
Species unidentifiable		UNKNOWN	**RHE**	**R**	

Key to Alpine & Upland Grassland Dominance Types

Instructions:

1. Codes for dominance type and vegetation type map unit can be found using Table 5. Find the name of the most abundant graminoid in column 1 and move to column 2 for the dominance type code, column 3 for the vegetation type map unit code, and column 4 for the vegetation map group code.
2. When two or more graminoid species are equal in abundance, the species listed with the lowest rank number in Table 5 column 5 is used to assign the dominance type and vegetation type map unit.
3. If the most abundant graminoid species is not listed in Table 5, then consult with the Regional Ecologist to assign a dominance type and map unit.

Table 5. Most Abundant Upland Graminoid and Indicated Dominance Type and Veg. Type Map Unit.

(1) Most Abundant Graminoid (Dominance Type)		(2) Dom. Type Code	(3) Veg Type Map Unit	(4) Veg Group	(5) Rank
Achnatherum hymenoides	Indian ricegrass	ACHY	**UHE**	**H**	15
Achnatherum lettermanii	Letterman's needlegrass	ACLE9	***TBD**	**A or H**	
Achnatherum nelsonii	Columbia needlegrass	ACNE9	**UHE**	**H**	19
Agropyron cristatum	crested wheatgrass	AGCR	**UHE**	**H**	37
Agrostis variablis	mountain bentgrass	AGVA-U	***TBD**	**A or H**	
Alopecurus pratensis	meadow foxtail	ALPR3	**UHE**	**H**	7
Aristida purpurea	purple threeawn	ARPU9	**UHE**	**H**	45
Blepharoneuron tricholepis	pine dropseed	BLTR	***TBD**	**A or H**	
Bouteloua gracilis	blue grama	BOGR2	**UHE**	**H**	22
Bromus anomalus	nodding brome	BRAN	**UHE**	**H**	27
Bromus inermis	smooth brome	BRIN2-U	**UHE**	**H**	38
Bromus marginatus	mountain brome	BRMA4	**UHE**	**H**	11
Bromus rubens	red brome	BRRU2	**UHE**	**H**	46
Bromus tectorum	cheatgrass	BRTE	**UHE**	**H**	47
Carex albonigra	blackandwhite sedge	CAAL6	**ALP**	**A**	2
Carex arapahoensis	Arapaho sedge	CAAR13	**ALP**	**A**	1
Carex duriuscula	needleleaf sedge	CADU6	**UHE**	**H**	25
Carex elynoides	blackroot sedge	CAEL3	***TBD**	**A or H**	
Carex haydeniana	cloud sedge	CAHA6-U	***TBD**	**A or H**	
Carex microptera	smallwing sedge	CAMI7-U	***TBD**	**A or H**	
Carex obtusata	obtuse sedge	CAOB4	***TBD**	**A or H**	
Carex occidentalis	western sedge	CAOC2	**UHE**	**H**	26
Carex phaeocephala	dunhead sedge	CAPH2	***TBD**	**A or H**	
Carex praegracilis	clustered field sedge	CAPR5-U	**UHE**	**H**	6
Carex rossii	Ross' sedge	CARO5	***TBD**	**A or H**	
Carex scirpoidea	northern singlespike sedge	CASC10	***TBD**	**A or H**	
Carex subnigricans	nearlyblack sedge	CASU7	**UHE**	**H**	17
Dactylis glomerata	orchardgrass	DAGL	**UHE**	**H**	36
Danthonia intermedia	timber oatgrass	DAIN	***TBD**	**A or H**	
Deschampsia cespitosa	tufted hairgrass	DECE-U	***TBD**	**A or H**	
Elymus elymoides	squirreltail	ELEL5	**UHE**	**H**	29
Elymus glaucus	blue wildrye	ELGL	**UHE**	**H**	10
Elymus lanceolatus	thickspike wheatgrass	ELLA3	**UHE**	**H**	20
Elymus scribneri	spreading wheatgrass	ELSC4	**UHE**	**H**	31
Elymus trachycaulus	slender wheatgrass	ELTR7	***TBD**	**A or H**	
Festuca brachyphylla (F.ovina)	alpine (sheep) fescue	FEBR	**ALP**	**A**	3
Festuca idahoensis	Idaho fescue	FEIDI2	**UHE**	**H**	13
Festuca thurberi	Thurber's fescue	FETH	**UHE**	**H**	12
Hesperostipa comata	needle and thread	HECO26	**UHE**	**H**	16
Hordeum brachyantherum	meadow barley	HOBR2	**UHE**	**H**	42
Juncus arcticus ssp. litoralis	mountain rush (baltic)	JUAR2-U	**UHE**	**H**	5

(1) Most Abundant Graminoid (Dominance Type)		(2) Dom. Type Code	(3) Veg Type Map Unit	(4) Veg Group	(5) Rank
Juncus drummondii	Drummond's rush	JUDR-U	***TBD**	**A or H**	
Koeleria macrantha	prairie Junegrass	KOMA	**UHE**	**H**	9
Leymus cinereus	basin wildrye	LECI4	**UHE**	**H**	8
Leymus salinus ssp. salinus	saline wildrye	LESAS	***TBD**	**A or H**	
Muhlenbergia montana	mountain muhly	MUMO	**UHE**	**H**	28
Muhlenbergia pungens	sandhill muhly	MUPU2	**UHE**	**H**	30
Muhlenbergia richardsonis	mat muhly	MURI	**UHE**	**H**	18
Pascopyrum smithii	western wheatgrass	PASM	**UHE**	**H**	21
Phleum alpinum	alpine timothy	PHAL2	**ALP**	**A**	4
Phleum pratense	timothy	PHPR3	**UHE**	**H**	35
Piptatheropsis micrantha	littleseed ricegrass	PIMI	**UHE**	**H**	23
Pleuraphis jamesii	James' galleta	PLJA	**UHE**	**H**	24
Poa arctica	arctic bluegrass	POAR2	***TBD**	**A or H**	
Poa bulbosa	bulbous bluegrass	POBU	**UHE**	**H**	48
Poa fendleriana	muttongrass	POFE	***TBD**	**A or H**	
Poa glauca var. glauca	glaucous bluegrass	POGLG	***TBD**	**A or H**	
Poa pratensis	Kentucky bluegrass	POPR-U	**UHE**	**H**	43
Poa secunda ssp. juncifolia	big bluegrass	POSEJ	**UHE**	**H**	32
Poa secunda ssp. secunda	Sandberg bluegrass	POSES6	**UHE**	**H**	33
Psathyrostachys juncea	Russian wildrye	PSJU3	**UHE**	**H**	39
Pseudoroegneria spicata	bluebunch wheatgrass	PSSP6	**UHE**	**H**	14
Secale cereale	cereal rye	SECE	**UHE**	**H**	40
Sporobolus cryptandrus	sand dropseed	SPCR	**UHE**	**H**	34
Thinopyrum intermedium	intermediate wheatgrass	THIN6	**UHE**	**H**	41
Trisetum spicatum	spike trisetum	TRSP2	***TBD**	**A or H**	
Vulpia octoflora	sixweeks fescue	VUOC	**UHE**	**H**	49
Species not listed above		**See Instruction 3 above**		**H**	
Species unidentifiable		**UNKNOWN**		**H**	

*TBD (To Be Determined) as within the Alpine or Upland Herbland Vegetation Type Map Unit: Assigned by field personnel on site. These species can be dominant in the alpine setting (most often above 10,800 feet in the mapping area) or within the more broadly defined Upland Herbland Map Unit. Choose either Alpine or Upland depending on what best describes the site by physical habitat setting.

Forbland Key

Dominance Types

Instructions:

Plots or polygons should be keyed out based on total cover by species. This key is divided into riparian and alpine/upland sections. First, identify the physical setting of the plot, stand, or polygon using the key below.

For the purposes of this key, a riparian setting is defined as an area (typically transitional between aquatic and terrestrial ecosystems) identified by soil characteristics associated with at least seasonally high water tables, distinctive vegetation that requires or tolerates free or unbound water (Manning and Padgett 1995), proximity to a stream or lake, and/or topographic position (e.g., valley bottom). The alpine setting includes the area above the upper limit of continuous forest. Above this limit trees occur only in scattered patches and become increasingly stunted at higher elevations (Arno and Hammerly 1984). In this key, the alpine setting takes precedence over the riparian setting. The upland setting includes non-riparian areas below the continuous forest line.

It is likely that some dominance types occur in more than one of these settings. If your plot does not key out successfully in one setting, then try another setting. For example, slender cinquefoil is in the upland key but may occur in riparian areas.

Key to Physical Habitat Setting

Key Leads:

1a		Stand is located in an alpine setting above the upper elevation limit of continuous forest…………………………………………………………………………	**Go to Alpine & Upland Key (p.21)**
1b		Stand is located below the upper elevation limit of continuous forest……………	**2**
	2a	Stand is located in a riparian setting as indicated by proximity to a stream or lake, topographic position, plant species that require or tolerate free or unbound water, and/or soil properties associated with seasonally high water tables………………………………………………………………………………………	**Go to Riparian Key (p.20)**
	2b	Stand not located in a riparian setting as described above……………………….	**Go to Alpine & Upland Key (p.21)**

Key to Riparian Forbland Dominance Types

Instructions:

1. Codes for dominance type and vegetation type map unit can be found using Table 6. Find the name of the most abundant forb in column 1 and move to column 2 for the dominance type code, column 3 for the vegetation type map unit code, and column 4 for the vegetation map group code.
2. When two or more forb species are equal in abundance, the species listed with the lowest rank number in Table 6 column 5 is used to assign the dominance type and vegetation type map unit.
3. If the most abundant forb species is not listed in Table 6, then consult with the Regional Ecologist to assign a dominance type and map unit.

Table 6. Most Abundant Riparian Forb and Indicated Dominance Type and Veg. Type Map Unit.

(1) Most Abundant Forb (Dominance Type)		(2) Dom. Type Code	(3) Veg Type Map Unit	(4) Veg Group	(5) Rank
Angelica pinnata	small-leaf angelica	ANPI2-R	**RHE**	**R**	9
Astragalus agrestis	purple milkvetch	ASAG2-R	**RHE**	**R**	13
Athyrium filix-femina	common ladyfern	ATFI	**RHE**	**R**	10
Brickellia californica	California brickellbush	BRCA3 -R	**RHE**	**R**	14
Caltha leptosepala	white marsh marigold	CALE4-R	**RHE**	**R**	1
Cirsium arvense	Canada thistle	CIAR4	**RHE**	**R**	35
Cirsium scariosum	meadow thistle	CISC2-R	**RHE**	**R**	15
Clematis ligusticifolia	western white clematis	CLLI2	**RHE**	**R**	16
Descurainia incana	mountain tansymustard	DEIN5-R	**RHE**	**R**	29
Equisetum arvense	field horsetail	EQAR-R	**RHE**	**R**	24
Erigeron ursinus	Bear River fleabane	ERUR2-R	**RHE**	**R**	30
Eurybia glauca	gray aster	EUGL19-R	**RHE**	**R**	17
Fragaria sp.	Strawberry	FRAGA	**RHE**	**R**	38
Heracleum maximum	common cowparsnip	HEMA80	**RHE**	**R**	8
Iris missouriensis	Rocky Mountain iris	IRMI	**RHE**	**R**	36
Lathyrus lanszwertii	Nevada pea	LALA3-R	**RHE**	**R**	18
Ligusticum porteri	Porter's licorice-root	LIPO-R	**RHE**	**R**	19
Melilotus officinalis	sweetclover	MEOF	**RHE**	**R**	31
Mertensia arizonica	aspen bluebells	MEAR6-R	**RHE**	**R**	5
Mertensia ciliata	tall fringed bluebells	MECI3	**RHE**	**R**	6
Nasturtium officinale	watercress	NAOF	**RHE**	**R**	3
Osmorhiza depauperata	bluntseed sweetroot	OSDE-R	**RHE**	**R**	20
Pedicularis groenlandica	elephanthead lousewort	PEGR2	**RHE**	**R**	4
Potentilla gracilis	slender cinquefoil	POGR9-R	**RHE**	**R**	32
Pyrrocoma lanceolata var. *lanceolata*	lanceleaf goldenweed	PYLAL-R	**RHE**	**R**	21
Senecio triangularis	arrowleaf ragwort	SETR	**RHE**	**R**	7
Solidago velutina	threenerve goldenrod	SOVE6-R	**RHE**	**R**	22
Symphyotrichum ascendens	western aster	SYAS3-R	**RHE**	**R**	25
Symphyotrichum eatonii	Eaton's aster	SYEA2-R	**RHE**	**R**	26
Taraxacum officinale	common dandelion	TAOF-R	**RHE**	**R**	33
Trifolium longipes	longstalk clover	TRLO-R	**RHE**	**R**	27
Trifolium repens	white clover	TRRE3-R	**RHE**	**R**	28
Typha domingensis	southern cattail	TYDO	**RHE**	**R**	2
Urtica dioica	stinging nettle	URDI	**RHE**	**R**	37
Veratrum californicum	California false hellebore	VECA2	**RHE**	**R**	34
Veronica americana	American speedwell	VEAM2	**RHE**	**R**	11
Veronica anagallis-aquatica	water speedwell	VEAN2	**RHE**	**R**	12
Vicia americana	American vetch	VIAM-R	**RHE**	**R**	23
Species not listed above		See Instruction 3 above	**RHE**	**R**	
Species unidentifiable		UNKNOWN	**RHE**	**R**	

Key to Alpine & Upland Forbland Dominance Types

Instructions:

1. Codes for dominance type and vegetation type map unit can be found using Table 7. Find the name of the most abundant forb in column 1 and move to column 2 for the dominance type code, column 3 for the vegetation type map unit code, and column 4 for the vegetation map group code.
2. When two or more forb species are equal in abundance, the species listed with the lowest rank number in Table 7 column 5 is used to assign the dominance type and vegetation type map unit.
3. If the most abundant forb species is not listed in Table 7, then consult with the Regional Ecologist to assign a dominance type and map unit.

Table 7. Most Abundant Upland Forb and Indicated Dominance Type and Veg. Type Map Unit.

(1) Most Abundant Forb (Dominance Type)		(2) Dom Type Code	(3) Veg Type Map Unit	(4) Veg Group	(5) Rank
Achillea millefolium	common yarrow	ACMI2	***TBD**	**A or H**	
Angelica pinnata	small-leaf angelica	ANPI2-U	***TBD**	**A or H**	
Antennaria microphylla	littleleaf pussytoes	ANMI3-U	***TBD**	**A or H**	
Antennaria rosulata	Kaibab pussytoes	ANRO3	***TBD**	**A or H**	
Arenaria congesta	Ballhead sandwort	ARCO5	***TBD**	**A or H**	
Artemisia ludoviciana	white sagebrush	ARLU	**UHE**	**H**	29
Artemisia campestris	field sagewort	ARCA12	**UHE**	**H**	68
Artemisia dracunculus	tarragon	ARDR4	**UHE**	**H**	35
Artemisia michauxiana	Michaux's wormwood	ARMI4	**UHE**	**H**	69
Astragalus agrestis	purple milkvetch	ASAG2-U	**UHE**	**H**	6
Astragalus argophyllus	silverleaf milkvetch	ASAR4	**UHE**	**H**	42
Astragalus lonchocarpus	rushy milkvetch	ASLO3	**UHE**	**H**	84
Astragalus miser	timber milkvetch	ASMI9-U	***TBD**	**A or H**	
Astragalus subcinereus	Silver's milkvetch	ASSU6	**UHE**	**H**	70
Astragalus tenellus	looseflower milkvetch	ASTE5	**UHE**	**H**	36
Atriplex saccaria	sack saltbush	ATSA	**UHE**	**H**	43
Balsamorhiza sagittata	arrowleaf balsamroot	BASA3	**UHE**	**H**	26
Brickellia californica	California brickellbush	BRCA3-U	**UHE**	**H**	7
Caltha leptosepala	white marsh marigold	CALE4-U	***TBD**	**A or H**	
Cardaria draba	whitetop	CADR	**UHE**	**H**	92
Carduus nutans	nodding plumeless thistle	CANU4	**UHE**	**H**	93
Ceratocephala testiculata	curveseed butterwort	CETE5	**UHE**	**H**	105
Chamerion angustifolium	fireweed	CHAN9	**UHE**	**H**	33
Chenopodium atrovirens	pinyon goosefoot	CHAT	**UHE**	**H**	94
Chorispora tenella	crossflower	CHTE2	**UHE**	**H**	103
Cirsium scariosum	meadow thistle	CISC2-U	**UHE**	**H**	8
Cirsium subniveum	Jackson Hole thistle	CISU	**UHE**	**H**	87
Cirsium wheeleri	Wheeler's thistle	CIWH	**UHE**	**H**	86
Collinsia parviflora	maiden blue eyed Mary	COPA3	**UHE**	**H**	40
Cryptantha fulvocanescens	tawny cryptantha	CRFU	**UHE**	**H**	67
Cryptantha gracilis	narrowstem cryptantha	CRGR3	**UHE**	**H**	106
Delphinium barbeyi	subalpine larkspur	DEBA2	**UHE**	**H**	21
Delphinium nuttallianum	twolobe larkspur	DENU2	**UHE**	**H**	44
Descurainia incana	mountain tansymustard	DEIN5-U	**UHE**	**H**	95
Descurainia pinnata	western tansymustard	DEPI	**UHE**	**H**	107
Epilobium brachycarpum	tall annual willowherb	EPBR3	**UHE**	**H**	34
Equisetum arvense	field horsetail	EQAR-U	**UHE**	**H**	14
Erigeron compositus	cutleaf daisy	ERCO4	***TBD**	**A or H**	
Erigeron divergens	spreading fleabane	ERDI4	**UHE**	**H**	63
Erigeron flagellaris	trailing fleabane	ERFL	**UHE**	**H**	37
Erigeron mancus	depauperate fleabane	ERMA9	**ALP**	**A**	4

(1) Most Abundant Forb (Dominance Type)		(2) Dom Type Code	(3) Veg Type Map Unit	(4) Veg Group	(5) Rank
Erigeron pumilus	shaggy fleabane	ERPU2	**UHE**	**H**	45
Erigeron religiosus	Clear Creek fleabane	ERRE7	**UHE**	**H**	71
Erigeron simplex	onestem fleabane	ERSI3	**UHE**	**H**	72
Erigeron speciosus	aspen fleabane	ERSP4	**UHE**	**H**	41
Eriogonum brevicaule	shortstem buckwheat	ERBRB4	**UHE**	**H**	47
Eriogonum corymbosum	crispleaf buckwheat	ERCO14	**UHE**	**H**	46
Erodium cicutarium	redstem stork's bill	ERCI6	**UHE**	**H**	108
Eurybia glauca	gray aster	EUGL19-U	**UHE**	**H**	9
Geranium richardsonii	Richardson's geranium	GERI	**UHE**	**H**	85
Geranium viscosissimum	sticky purple geranium	GEVI2	**UHE**	**H**	25
Geum rossii	Ross' avens	GERO2	**ALP**	**A**	1
Grindelia squarrosa	curlycup gumweed	GRSQ	**UHE**	**H**	98
Hackelia floribunda	manyflower stickseed	HAFL2	**UHE**	**H**	22
Halogeton glomeratus	saltlover	HAGL	**UHE**	**H**	102
Hedysarum boreale	Utah sweetvetch	HEBO	**UHE**	**H**	48
Helianthella uniflora	oneflower helianthella	HEUN	**UHE**	**H**	28
Heliomeris multiflora var. multiflora	showy goldeneye	HEMUM	**UHE**	**H**	49
Heterotheca villosa	hairy false goldenaster	HEVI4	**UHE**	**H**	50
Hymenopappus filifolius	fineleaf hymenopappus	HYFI	**UHE**	**H**	73
Hymenoxys hoopesii	orange sneezeweed	HYHO	**UHE**	**H**	10
Hymenoxys richardsonii	pingue rubberweed	HYRI	**UHE**	**H**	51
Iliamna rivularis	streambank wild hollyhock	ILRI	**UHE**	**H**	20
Ivesia gordonii	Gordon's ivesia	IVGO	***TBD**	**A or H**	
Ivesia sabulosa	Intermountain mousetail	IVSA	**UHE**	**H**	79
Lappula occidentalis	flatspine stickseed	LAOC3	**UHE**	**H**	100
Lathyrus lanszwertii	Nevada pea	LALA3-U	**UHE**	**H**	19
Lepidium fremontii	desert pepperweed	LEFR2	**UHE**	**H**	77
Leucocrinum montanum	common starlily	LEMO4	**UHE**	**H**	52
Ligusticum porteri	Porter's licorice-root	LIPO-U	**UHE**	**H**	13
Linum perenne	blue flax	LIPE2	**UHE**	**H**	64
Lotus humistratus	foothill deervetch	LOHU2	**UHE**	**H**	96
Lupinus argenteus	silvery lupine	LUAR3	**UHE**	**H**	31
Lupinus sericeus	silky lupine	LUSE2	**UHE**	**H**	32
Machaeranthera bigelovii var. commixta	Bigelow's tansyaster	MABIC	**UHE**	**H**	38
Machaeranthera canescens	hoary tansyaster	MACA2	**UHE**	**H**	74
Madia glomerata	mountain tarweed	MAGL2	**UHE**	**H**	97
Medicago sativa	alfalfa	MESA	**UHE**	**H**	90
Mertensia arizonica	aspen bluebells	MEAR6-U	**UHE**	**H**	5
Microsteris gracilis	slender phlox	MIGR	**UHE**	**H**	110
Monardella odoratissima	mountain monardella	MOOD	***TBD**	**A or H**	
Oenothera pallida	pale evening primrose	OEPA	**UHE**	**H**	75
Onobrychis viciifolia	sainfoin	ONVI	**UHE**	**H**	91
Onopordum acanthium	Scotch cottonthistle	ONAC	**UHE**	**H**	104
Orthocarpus tolmiei	Tolmie's owl's-clover	ORTO	**UHE**	**H**	62
Osmorhiza depauperata	bluntseed sweetroot	OSDE-U	**UHE**	**H**	15
Oxytropis lambertii	purple locoweed	OXLA3	**UHE**	**H**	78
Oxytropis oreophila	mountain oxytrope	OXOR2-U	***TBD**	**A or H**	
Packera multilobata	lobeleaf groundsel	PAMU11	**UHE**	**H**	65
Paronychia sessiliflora	creeping nailwort	PASE	**UHE**	**H**	80
Penstemon linarioides	toadflax penstemon	PELI2	**UHE**	**H**	54
Penstemon pachyphyllus	thickleaf beardtongue	PEPA6	**UHE**	**H**	55
Penstemon procerus	littleflower penstemon	PEPR2	***TBD**	**A or H**	
Penstemon rydbergii	Rydberg's penstemon	PERY	**UHE**	**H**	39

(1) Most Abundant Forb (Dominance Type)		(2) Dom Type Code	(3) Veg Type Map Unit	(4) Veg Group	(5) Rank
Penstemon watsonii	Watson's penstemon	PEWA	**UHE**	**H**	56
Petradoria pumila	rock goldenrod	PEPU7	**UHE**	**H**	57
Petrophytum caespitosum	mat rockspirea	PECA12	**UHE**	**H**	81
Phlox austromontana	mountain phlox	PHAU3	**UHE**	**H**	66
Phlox pulvinata	cushion phlox	PHPU5	***TBD**	**A or H**	
Pleiacanthus spinosus	thorn skeletonweed	PLSP7	**UHE**	**H**	88
Polemonium foliosissimum	towering Jacob's-ladder	POFO	**ALP**	**A**	3
Potentilla arguta	tall cinquefoil	POAR7	**UHE**	**H**	27
Potentilla diversifolia	varileaf cinquefoil	PODI2	***TBD**	**A or H**	
Potentilla gracilis	slender cinquefoil	POGR9-U	***TBD**	**A or H**	
Potentilla hippiana	woolly cinquefoil	POHI6	***TBD**	**A or H**	
Pyrrocoma lanceolata var. lanceolata	lanceleaf goldenweed	PYLAL-U	**UHE**	**H**	12
Rudbeckia occidentalis	western coneflower	RUOC2	**UHE**	**H**	23
Salsola tragus	prickly Russian thistle	SATR12	**UHE**	**H**	99
Senecio atratus	tall blacktip ragwort	SEAT	**UHE**	**H**	82
Senecio eremophilus	desert ragwort	SEER2	**UHE**	**H**	83
Senecio flaccidus var. douglasii	Douglas' ragwort	SEFLD	**UHE**	**H**	76
Senecio integerrimus	lambstongue ragwort	SEIN2	**UHE**	**H**	58
Sibbaldia procumbens	creeping sibbaldia	SIPR	**ALP**	**A**	2
Sisymbrium altissimum	tall tumblemustard	SIAL2	**UHE**	**H**	101
Solidago multiradiata	Rocky Mountain goldenrod	SOMU-U	***TBD**	**A or H**	
Solidago velutina	threenerve goldenrod	SOVE6-U	**UHE**	**H**	18
Sphaeralcea coccinea	scarlet globemallow	SPCO	**UHE**	**H**	89
Stenotus armerioides var. armerioides	thrift mock goldenweed	STARA	**UHE**	**H**	59
Symphyotrichum ascendens	western aster	SYAS3-U	***TBD**	**A or H**	
Symphyotrichum eatonii	Eaton's aster	SYEA2-U	**UHE**	**H**	16
Taraxacum officinale	common dandelion	TAOF-U	***TBD**	**A or H**	
Tetraneuris acaulis var. acaulis	stemless four-nerve daisy	TEACA2	**UHE**	**H**	60
Thalictrum fendleri	Fendler's meadow-rue	THFE	**UHE**	**H**	24
Thermopsis montana	mountain goldenbanner	THMO6	***TBD**	**A or H**	
Trifolium kingii ssp. macilentum	King's clover	TRKIM	**UHE**	**H**	61
Trifolium longipes	longstalk clover	TRLO-U	***TBD**	**A or H**	
Trifolium repens	white clover	TRRE3-U	**UHE**	**H**	17
Verbascum thapsus	common mullein	VETH	**UHE**	**H**	109
Vicia americana	American vetch	VIAM-U	**UHE**	**H**	11
Wyethia amplexicaulis	mule-ears	WYAM	**UHE**	**H**	30
Xylorhiza confertifolia	Henrieville woodyaster	XYCO3	**UHE**	**H**	53
Species not listed above		**See Instruction 3 above**		**H**	
Species unidentifiable		**UNKNOWN**		**H**	

*TBD (To Be Determined) as within the Alpine or Upland Herbland Vegetation Type Map Unit: Assigned by field personnel on site. These species can be dominant in the alpine setting (most often above 10,800 feet in the mapping area) or within the more broadly defined Upland Herbland Map Unit. Choose either Alpine or Upland depending on what best describes the site by physical habitat setting.

Non-Vegetated and Land Use Types Key*

			Map Unit	Group
1a		Area is currently used for agricultural activity (e.g., a fallow field)……..……	**AGR**	**N**
1b		Area is not currently used for agricultural activity………………………………	**2**	
	2a	Area is currently developed for urban, residential, administrative use………..	**DEV**	**N**
	2b	Area is not currently developed for urban, residential, administrative use……	**3**	
3a		Area is dominated by open water or a confined watercourse…………………	**WA**	**N**
3b		Area is not dominated by open water or confined watercourse………………..	**4**	
	4a	Area is dominated by unburned barren land (e.g. bedrock, cliffs, scree, and talus) with all vascular plants total < 1% absolute canopy cover……………....	**BR/SV**	**N**
	4b	Area is not dominated by unburned barren land………………………………....	**5**	
5a		Area is dominated by non-vascular species (mosses, liverworts, hornworts, lichens, algae and fungus) with all vascular plants total < 1% absolute canopy cover..	**BR/SV**	**N**
5b		Area not dominated by non-vascular species …………………………………	**Undefined**	

*Dominance Types (D.T) is not applicable for Non-Vegetated and Land Use Types.

References:

Arno, S.F. and R.P. Hammerly. 1984. Timberline: Mountain and Arctic Forest Frontiers. The Mountaineers, Seattle.

Manning, M.E. and W.G. Padgett. 1995. Riparian Community Type Classification for Humboldt and Toiyabe National Forests, Nevada and Eastern California. U.S. Department of Agriculture, Forest Service, Intermountain Region, p. 306.

Appendix A:

Absolute and Relative Cover

Absolute cover of a plant species is the proportion of a plot's area included in the perpendicular downward projection of the species. These are the values recorded when sampling a vegetation plot. Relative cover of a species is the proportion it composes of the total plant cover on the plot (or the proportion of a layer's cover). Relative cover values must be calculated from absolute cover values. For example, we estimate overstory canopy cover on a plot as follows: ponderosa pine 42%, white fir 21%, and aspen 7%. These values are the absolute cover of each species. The relative cover of each species is calculated by dividing each absolute cover value by their total (70%) as follows:

	Absolute Cover	Calculation	Relative Cover
Ponderosa pine	42%	100 x 42 / 70 =	60%
White fir	21%	100 x 21 /70 =	30%
Aspen	7%	100 x 7 /70 =	10%
Total of values	70%		100%

We calculate relative cover of 60% for ponderosa pine. This means that ponderosa pine makes up 60% of the overstory tree canopy cover on the plot. Relative cover always adds up to 100%, but absolute cover does not. Because plant canopies can overlap each other, absolute cover values can add up to more than 100%. In our example, the total of the absolute cover values is 70, but this does not mean that overstory trees cover 70% of the plot. Overstory tree cover would be 70% if there were no overlap among the crowns of the three species, but only 42% with maximum overlap. The actual overstory cover must be determined when sampling the plot if the information is desired, but the sum of the species cover values is used to calculate relative cover.

If the absolute cover values in our example were all halved or all doubled, the relative cover of each species would not change even though overstory tree cover would be very different. Halving the absolute values would mean overstory cover would be between 21 and 35%, depending on the amount of overlap. Doubling the values would mean overstory cover could range from 84 to 100% (not 140%). Each of these scenarios would be very different from the original example in terms of wildlife habitat value, fuel conditions, fire behavior, and silvicultural options; but the relative cover of the tree species would be exactly the same. We should also note that they also could vary widely in spectral signature. The key point here is that relative cover values by themselves provide limited ecological information and may be of little value to resource managers. Relative cover can be derived from absolute cover, but absolute cover cannot be derived from relative cover values. This is why absolute cover is recorded in the field.

Appendix B:

Map Group	Code
Alpine	**A**
Riparian	**R**
Herbland	**H**
Shrubland	**S**
Conifer Forest	**C**
Deciduous Forest	**D**
Woodland	**W**
Non-Vegetated/Sparse Vegetation	**N**

Vegetation Group and Vegetation Type Map Unit	Code
Alpine	**A**
Alpine Vegetation – *inclusive of alpine shrubs*	ALP
Riparian	**R**
Riparian Herbaceous (Stream & Meadow – Wet)	RHE
Riparian Woody (Stream & Meadow – Wet)	RW
Herbland	**H**
Upland Herbaceous – inclusive of moist to dry meadows	UHE
Shrubland	**S**
Black Sagebrush	BLSB
Mountain Big Sagebrush	MSB
Mountain Shrubland	MS
Silver Sagebrush	SSB
Wyoming/Basin Big Sagebrush	WSB/BSB
Conifer Forest	**C**
Bristlecone Pine/Limber Pine	BC/LM
Douglas-fir Mix	DFmix
Spruce/Fir	SF
Ponderosa Pine Mix	PPmix
White Fir	WF
White Fir Mix	WFmix
Deciduous Forest	**D**
Aspen	AS
Aspen/Conifer	AS/C
Woodland	**W**
Mountain Mahogany	MM
Gambel Oak	GO
Pinyon-Juniper	PJ
Rocky Mountain Juniper Mix	RMJmix
Non-Vegetated/Sparse Vegetation	**N**
Agriculture	AGR
Barren/Sparse Vegetation	BR/SV
Developed	DEV
Unknown	UNK
Water	WA

Appendix D: Field Reference Data Collection Guide and Protocols

Manti-La Sal & Fishlake National Forests
Existing Vegetation Mapping Project
Field Reference Data Collection Protocol
5/16/2014

Introduction

This document describes the field reference data collection procedures for the Manti-La Sal and Fishlake National Forest Existing Vegetation Mapping Project. Topics covered in this guide include an overview of field reference site selection, a description of sites and types of plots, field materials, data collection protocols, and detailed instructions on populating the field data form. These procedures have been established following direction in the USFS Existing Vegetation Classification and Mapping Technical Guide (GTR WO-67) as well as guidelines from the Remote Sensing Applications Center and Intermountain Region.

Background

The Manti-La Sal and Fishlake National Forests are responsible for managing vegetation to meet a variety of uses while sustaining and restoring the integrity, biodiversity, and productivity of ecosystem components and processes. In building the knowledgebase required to accomplish this mission, existing vegetation information is collected through an integrated classification, mapping, and quantitative inventory process. This information structure is essential for conducting landscape analyses and assessments, developing conservation and restoration strategies, and revising land management plans that guide project development and implementation.

The collected data will be used to create a mid-level (1:100,000 scale) map of current (existing) vegetation communities across the Manti-La Sal and Fishlake National Forests. Data gathered will include information on species composition, canopy cover, and tree diameter. Dominance type and corresponding vegetation type map unit are determined using the *Manti-La Sal and Fishlake Vegetation Keys.* Percent canopy cover and related canopy cover map unit are identified using ocular estimation and line intercept methods. Canopy cover is estimated based on an overhead or "birds-eye" view of the plot from above. Vegetation canopy overlap is not considered. Tree diameter and associated tree size map unit are determined using diameter at breast height or diameter at root collar estimates. All collected data will be recorded in electronic format in the field reference database.

Field Reference Site Selection

A primary objective of reference data collection is to sample the vegetation communities and other landcover types occurring across the project area. A sufficient number of field samples are required for each of the proposed vegetation types to be mapped. In an effort to meet this objective, 1,300 pre-selected reference sites have been distributed across the project area. In addition, 20 sites have been placed within the Dark Canyon Wilderness Area on the Manti-La Sal Monticello District.

To minimize variation in ecological and vegetation characteristics for the purposes of modeling and mapping across expansive areas, the project area has been divided into two geographic areas (Figure 1). The number of sites allocated to each geographic area (GA) has been based on an analysis of existing vegetation data distributions, satellite image spectral variability, and the relative size of each GA. Approximately 900 sites have been placed in GA-1 and 400 sites in GA2 (subject to finalizing the project sample design). Within each GA, a multi-level stratification approach was used to 1) distribute a portion of sites evenly across an unsupervised satellite image spectral classification and 2) distribute the remaining sites based on the relative abundance of combined spectral and existing vegetation strata.

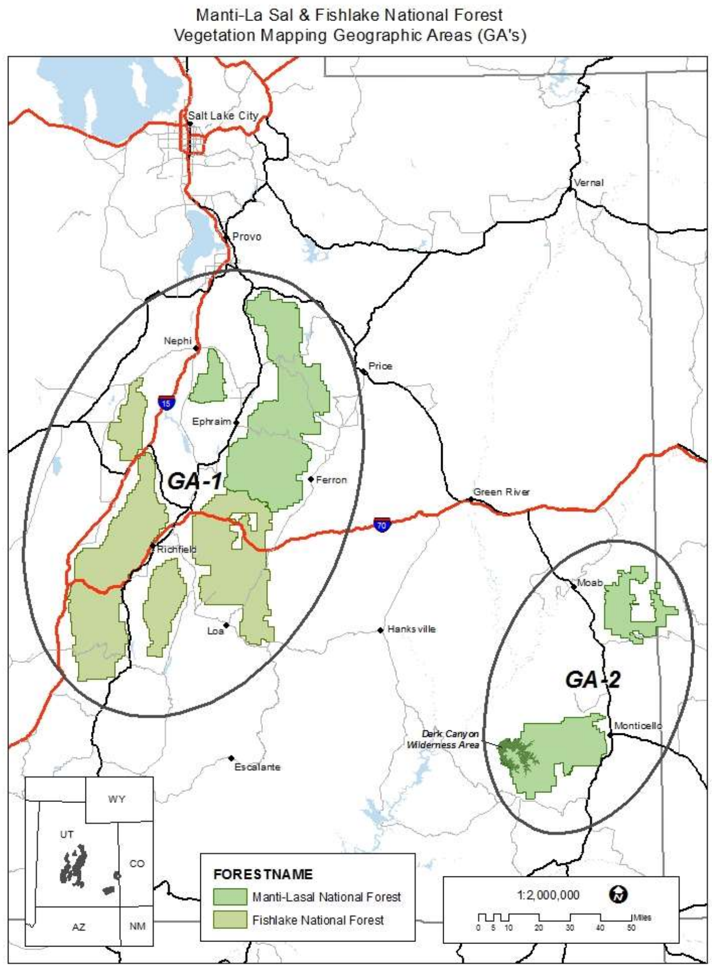


Figure 1. *Project Geographic Areas (GA's).*

Due to the inherent constraints in accessing remote and extensive areas across the entire project area, sites have generally been selected within a quarter mile of a road or along trails. Consequently, sites for this project do not constitute a random sample of the mapping area, and have not been established along a systematic grid or other sampling scheme. Some sites may be located behind gates of seasonally closed roads or in roadless areas. Any sites located in designated wilderness areas require non-motorized access and possible overnight camping.

Field Reference Sites and Types of Plots

Field reference sites consist of polygons representing relatively homogeneous vegetation patches or stands and non-vegetated elements. Each reference site contains a total of three plots, consisting of a predetermined number and distribution of *descriptive* and/or *observation* plots as described below. Of the 1,320 total reference sites, 820 sites contain a single descriptive plot and two observation plots. The remaining 500 sites contain three observation plots.

Field information is collected for two types of plots:

- Descriptive Plots
- Observation Plots

Descriptive Plots
Descriptive plots are established to collect vegetation composition data consisting of percent canopy cover by life form, canopy cover by species of the predominant life form, and tree species canopy cover by diameter class. For forest, woodland, and shrubland plots, canopy cover by species is estimated using ocular estimates, and optionally measured using line intercept transects. For herbaceous plots, ocular estimates are used to determine cover by graminoid and forb species. Finally, for forest and woodland plots, cover for tree species by diameter class is ocularly estimated. The resulting cover data are then applied to the vegetation keys and structure characteristic classifications to assign dominance type and map unit attributes including vegetation type, vegetation group, canopy cover and tree size.

Descriptive plots provide detailed information on dominance type and map unit description information, and help to calibrate field crews for *observation plot* estimates below. One descriptive plot is collected within 800 of the non-wilderness reference sites, and all 20 of the wilderness sites. No more than one descriptive plot is contained within a given a reference site.

Observation Plots
Observation plots are collected using ocular estimates to assign dominance type, and vegetation type, vegetation group, canopy cover, and tree size map unit attributes. Unlike descriptive plots, the purpose of collecting observation plots is to quickly and efficiently collect several plots across a reference site for characterizing composition and variability without collecting detailed information.

The number of observation plots collected within a reference site varies between two and three plots depending on whether the site contains a descriptive plot. No more than three observation plots are contained within a given reference site.

Provided Field Materials

Field crews have been provided the following field materials to support data collection.

- Field data collection protocol and forms: This guidance document and field data collection forms for recording reference site and plot information in the field. Procedures for collecting tree and shrub transect data are included in a separate document and form.
- Vegetation keys and map units: Dichotomous keys to vegetation formations and dominance types, and crosswalks to vegetation group and vegetation type map units. A summary of vegetation type map units and codes is found in the appendices to the keys and Appendix B of this document.

- Structural characteristic map units: Tree and shrub canopy cover, and tree size map units. Map units and codes are included on the field data collection form and in Appendix B of this document.
- Field reference site/plot list and digital plot waypoints: A list of reference site/plot ID's, and digital plot waypoints for uploading to GPS units.
- Field overview map: National Forest extent, poster-size map depicting all reference site locations and site ID's.
- Field gazetteer for navigation: Reduced extent maps displaying reference site locations, site ID's, and detailed travel routes.
- Plot maps: Limited extent, 8.5 x 11 inch, high resolution imagery maps containing the reference site polygon, and plot locations and coordinates (waypoints) within the polygon.

Sampling Process

The sampling process involves three main steps: planning, navigation, and data collection.

Step 1 - Planning
Before leaving the office, each crew should know where they are going, understand the information to be collected, and have the appropriate gear to complete the task. Review the overview and gazetteer navigation maps to determine the best travel routes. Check with your supervisor and/or crew lead before leaving. Coordinate with designated Forest personnel to ensure access before leaving for the field.

Gear check list:

- GPS unit	- Clinometer
- Digital camera	- Densitometer (optional)
- Batteries (GPS and camera)	- 100ft tape
- Gazetteer & plot maps	- Diameter tape
- Vegetation keys	- Compass
- Field data forms	- Biodegradable flagging
- Pencils	- Whiteboard or 3 x 5" cards, etc.

Step 2 - Navigation
You have been provided with the coordinates of the reference site centers, plot locations within the reference sites, a gazetteer for navigation, and individual reference site location maps depicting high resolution aerial imagery to aid in navigating (Figure 2). Digital waypoint coordinates should be preloaded on the GPS unit. Reference sites have been located generally within ¼ mile of a motorized route or foot trail in backcountry areas to make them readily accessible. However, there is no guarantee that sites will be accessible. If you cannot get to a site due to access limitations or

safety concerns, record it as not observable, note the specific reason(s), and move on to the next site.

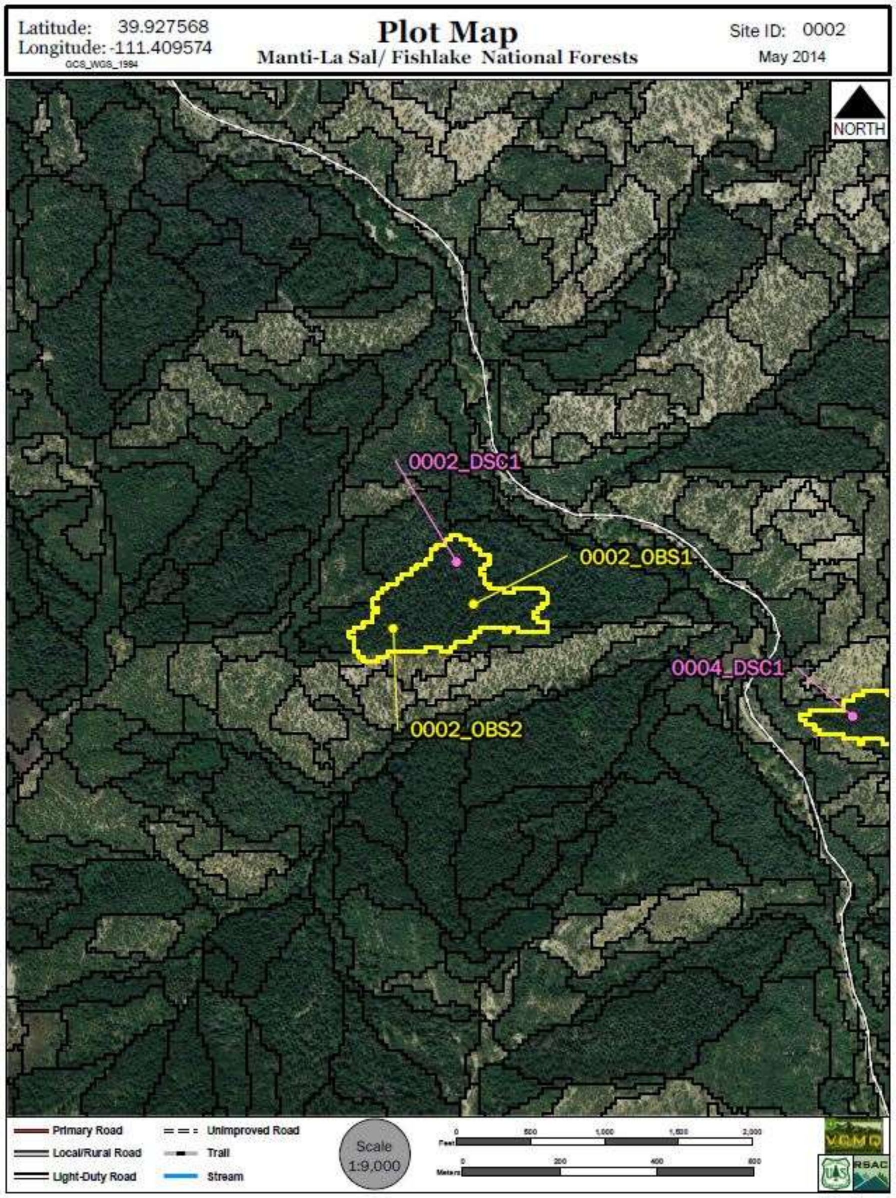


Figure 2. *Plot map depicting a reference site, site coordinates, descriptive and observation plot locations, and roads/trails.*

Step 3- Data Collection

<u>*Descriptive Plots*</u>

As previously noted, one descriptive plot is collected for 800 of the 1,300 reference sites. These plots are annotated on the plot map using the identifier *DSC* followed by the plot number. Navigate to the waypoint location and place flagging at the plot center. The dimension of each plot consists of a 50 foot radius circle *corrected for slope if 10 percent or greater*. Measure and flag the plot boundaries in each cardinal direction from the center of the plot. Do not adjust for magnetic declination. In designated wilderness areas, use sticks or rock cairns to mark the plot instead of flagging.

Estimate all vegetation data within the plot area from an overhead or "bird's-eye" view of the plot from above. Again, vegetation canopy overlap is not considered, therefore total vegetative/non-vegetative cover for the plot area must equal 100%. It is important to walk through the entire plot before recording the most abundant species, percent canopy cover, and cover by tree diameter class. It may also be helpful to mark out a 5 foot radius subplot representing 1 percent of the plot area to assist in calibrating your estimates.

Observation Plots

Between two and three observation plots are collected within each reference site. These plots are annotated on the plot map using the identifier *OBS* followed by the plot number. Again, navigate to the waypoint location of the plot and place flagging at the plot center. In designated wilderness areas, use sticks or rock cairns to mark the plot instead of flagging. The dimension of each plot consists of a 50 foot radius circle *corrected for slope if 10 percent or greater*. It is not necessary to flag the plot boundaries. Walk through the plot and apply the same logical procedures used for the descriptive plots to ocularly estimate a dominance type, and vegetation type, vegetation group, canopy cover, and tree size map unit. These plots are meant to be quick, using your best judgment based upon experience gained from collecting descriptive plots.

Data Collection Forms

This section provides information on how to populate the field data forms.

Field Reference Site Information

1. Reference Site ID: Record the 4-digit site number as identified on the plot map.

2. Names of collectors: Record the names of the personnel collecting the data by first initial and last name (e.g. J. Doe), or full names to maintain unique crew member identification as needed.

3. Month/Day/Year

4. Access Code: Record the reference site access code as "ACC" for accessible, and "NO" for not observable. (If any *plots* within the reference site are inaccessible, provide a comment in the Notes section for the individual plot.)

5. Geographic Area: Record the geographic area (GA) that the site is located in as identified on the plot map.

Descriptive Plot Data Items

6. Plot Type: The plot type is "DSC" for a descriptive plot

7. Plot ID: The plot ID is "1" for a descriptive plot (never more than one within a reference site).

8. Latitude/Longitude Decimal Degree Coordinates: Record the coordinates for the center of the plot. It is important to collect positions **from the plot center**, so be at the center to start collection. You should try to collect 180 readings or 100% sample confidence depending on the GPS unit. Fewer than 90 readings or 50% sample confidence must be documented in the Notes section.

   GPS units must be set to the following coordinate system:

   Latitude/Longitude Decimal Degrees
   WGS84

9. Field Photograph: Take a single representative photo of the plot (more can be taken if necessary) and record the digital photo number and bearing. Take the photo from the plot center in a direction that captures a representative view of the vegetation characteristics contained within the plot. Use a whiteboard or other placard depicting the plot identifier and direction including the reference site ID, plot type and number, and compass bearing direction (e.g. 1024-DSC1-90). Do not adjust for magnetic declination. Upon uploading the photos to a computer, ensure the files are named/renamed to match the plot identifier.

10. Ocular Plot Composition: (Estimated from an overhead perspective of the plot from above). Estimate and record the total canopy cover for each life form including tree, shrub, herbaceous (graminoids and forbs), and non-vegetated. See the vegetation keys for a list of species by life form. Determine percent cover as if you were looking down on the stand from above the plot; do not double count overlapping layers that are not viewable from above. For example, smaller-sized trees being overlapped by larger ones are ignored and not counted in the canopy cover estimate. The sum of canopy cover for trees, shrubs, herbaceous and non-vegetated must total 100%. If the dominant plant species encountered on the site consists of a forb or grass (e.g. cheatgrass - *Bromus tectorum*) in a senesced condition, record the appropriate plant symbol and estimated live percent cover of the plant instead of recording the cover as non-vegetated litter. Cover estimates for nonvascular life forms (e.g. lichen, moss, etc.) are included in the non-vegetated category.

    Based on the life form cover estimates, determine the dominant life form using the *Key to Vegetation Formations*. For the dominant life form identified, list up to the 5 most abundant species having ≥ 5% (11.2 foot radius circle) cover. For each species, record the USDA PLANTS symbol as found on the Manti-La Sal and Fishlake plant species list. If the symbol for any species is not known, its name should be written out and the symbol looked up later. If a plant can only be identified to the genus level (e.g. due to seasonal condition or disturbance), record only the plant genus and make a note of it on the form.

One exception exists where a species occurring with less than 5% cover is recorded. On a plot where the most abundant tree, shrub, or herbaceous species occurs with <5% cover, record the single most abundant species in order to determine dominance type and corresponding vegetation type and vegetation group map units.

For each of the species listed, estimate and record the percent canopy cover as viewed from above the plot. For the remaining species not individually listed (including individual species with <5% cover), estimate and record the combined percent cover for the "others combined" item on the form. Percent cover for *combined grasses* and *combined forbs* must be recorded separately. Species cover estimates must sum to the total life form cover estimate previously recorded.

11. <u>Tree Cover by Diameter Class:</u> (Only for Tree life form plots.) If tree canopy information has been collected using the optional transect protocol, list each tree species and canopy cover as recorded on the transect data form. However, if the ocular species cover estimates are considered to be more representative of the plot than the transect data, list each tree species and canopy cover as recorded in #10 and include a note in the Comments section below that the ocular estimates are considered more representative than the transect data.

    For each species, estimate the percent cover of each tree diameter class and enter it in the diameter class columns. Timber species less than 4.5 feet tall or woodland species less than 1.0" diameter at root collar are included in the smallest tree diameter class. For trees that are close to a diameter class boundary, measure diameter at breast height (DBH) or diameter at root collar (DRC) to calibrate ocular estimates. Total the estimated percent cover for each diameter class.

    Determine percent cover of each diameter class as if you were looking down on the stand from above the plot; do not double count overlapping layers that are not viewable from above. For example, smaller sized trees that are being overlapped by larger ones are ignored and not counted in the diameter class estimate. Overhead crown cover extending into the circular plot area from a stem residing outside or on the border of the plot is assigned to the tree diameter class of the corresponding stem.

    Tree diameter is determined by estimating DBH for all tree species except designated woodland species listed in Table 1. For woodland species, tree diameter is determined by estimating DRC. Instructions for measuring DRC for woodland species are contained in Appendix A.

Table 1. *DRC Measured Woodland Species*

JUOS	Juniperus osteosperma	Utah juniper
JUSC2	Juniperus scopulorum	Rocky Mountain juniper
ACGR3	Acer grandidentatum	bigtooth maple
CELE3	Cercocarpus ledifolius	curlleaf mountain mahogany
PIED	Pinus edulis	common pinyon
PIMO	Pinus monophylla	singleleaf pinyon
QUGA	Quercus gambelii	Gambel oak

12. Dominance Type: Determine and record the dominance type of the plot according to the vegetation keys. If the optional transect protocol are used to collect tree or shrub canopy cover, use the species transect cover measurements to determine the dominance type. However, if the ocular species cover estimates are considered to be more representative of the plot than the transect data, use the ocular estimates to determine dominance type and include a comment in the Notes section.

13. Vegetation Type Map Unit: Identify and record the vegetation type map unit for the dominance type of the plot as listed in the vegetation keys. A list of the vegetation type map units will be included in Appendix B.

14. Vegetation Group Map Unit: Identify and record the vegetation group map unit for the dominance type of the plot as listed in the vegetation keys. A list of the vegetation group map units will be found in Appendix B.

15. Canopy Cover Map Unit: (Only for Tree and Shrub life form plots.) Based on the life form and total life form percent canopy cover for the plot, determine and record the canopy cover map unit. For *upland tree* life form plots, record a tree cover map unit (Table B2) based on the total tree cover. Upland tree life form plots include all forest and woodland map units except Riparian Shrubland and Deciduous Forest (RSH). For *shrub* and *riparian tree* life form plots, record a shrub cover map unit (Table B3) based on the *total shrub* or *total tree* cover respectively. For example, a narrowleaf cottonwood plot is assigned to the RSH map unit; therefore a shrub canopy cover map unit is recorded for the plot.

    If the optional transect protocol was used to collect tree or shrub canopy cover, use the overall transect cover to determine the canopy cover map unit. However, the ocular estimate can be used if it is considered to be more representative of the plot than the transect data. If transect information was collected and the ocular estimate is used to determine the map unit, include a comment in the Notes section.

16. Tree Size Map Unit: (Only for Tree life form plots.) Based on the total tree canopy cover by diameter class (#11), determine the most abundant diameter class for the plot. In case of a tie, record the largest tree diameter class. For Conifer and Deciduous vegetation group plots,

determine and record the *Forest* tree size map unit (Table B4). For Woodland vegetation group plots, determine and record the *Woodland* tree size map unit (Table B5).

17. Notes: Include information on the vegetation conditions, disturbances, approximate age of the disturbance, observed threatened and endangered plant species, invasive plant species, and any other pertinent information that is not included in the field form. This description is often the most valuable piece of information about a plot and provides details that can have an effect on the mapping process.

Observation Plot Data Items

As noted previously, walk through the plot and apply the same logical procedures used for the descriptive plots to ocularly estimate dominance type and map unit attributes.

18. Plot Type: The plot type is "OBS" for an observation plot.

19. Plot ID: Record the 1-digit plot ID number.

20. Latitude/Longitude Decimal Degree Coordinates: Record the coordinates for the center of the plot using the procedures described for descriptive plots.

21. Field Photograph: Take a single representative photo of the plot using the procedures described for descriptive plots.

22. Dominance Type: Walk through the plot area and ocularly estimate the composition and cover to determine the dominance type of the plot using the vegetation keys.

23. Vegetation Type Map Unit: Identify the vegetation type map unit for the dominance type of the plot as listed in the vegetation keys.

24. Vegetation Group Map Unit: Identify the vegetation group map unit for the dominance type of the plot as listed in the vegetation keys.

25. Canopy Cover Map Unit: (Only for Tree and Shrub life form plots.) Walk through the plot area and ocularly estimate the canopy cover map unit.

26. Tree Size Map Unit: (Only for Tree life form plots.) Walk through the plot area and ocularly estimate the tree size map unit.

27. Notes: Include information on the vegetation conditions, disturbances, approximate age of the disturbance, observed threatened and endangered plant species, invasive plant species, and any other pertinent information that is not included in the field form.

Field Reference Site Summary

Reference site summary calls are determined based on the majority results from the descriptive and observation plots. In cases where no dominance type or map unit is assigned to a majority of the plots, or the plots are not considered representative of the site, estimate and record a representative dominance type or map unit based on a combination of plot results and observations made while traversing the site between plots. Observations of notably different dominance types or map units while traversing the site should be included in the Notes section.

28. Dominance Type: Determine and record the majority or representative dominance type within the site based on the descriptive and observation plots, and/or notes regarding other observations made while traversing the site.

29. Vegetation Type Map Unit: Identify the vegetation type map unit for the dominance type of the site as listed in the vegetation keys.

30. Vegetation Group Map Unit: Identify the vegetation group map unit for the dominance type of the site as listed in the vegetation keys.

31. Canopy Cover Map Unit: (Only for Tree and Shrub life form reference sites.) Determine and record the majority or representative canopy cover map unit within the site based on the descriptive and observation plots, and/or notes regarding other observations made while traversing the site.

32. Tree Size Map Unit: (Only for Tree life form reference sites.) Determine and record the majority or representative tree size map unit within the site based on the descriptive and observation plots, and/or notes regarding other observations made while traversing the site.

33. Disturbance Event: If there is evidence of a recent disturbance event (fire, timber harvest, insect outbreak, wind event, etc.) within approximately the last 5 years, check the appropriate box and include any relevant information in the notes section, such as whether the plot was previously forested, contains standing dead trees, etc.

34. Notes: Include observations of other notable dominance types or map units within the site and their relative abundance. Record any additional information pertinent to the site and/or site summary calls. Include information on the vegetation conditions, disturbances, approximate age of the disturbance, observed threatened and endangered plant species, invasive plant species, and any other pertinent information that is not included in the field form.

Appendix A.

Diameter at Root Collar (DRC)
(Adapted from Interior West Forest Inventory and Analysis P2 Field Procedures, V5.00)

For species requiring diameter at the root collar, measure the diameter at the ground line or at the stem root collar, whichever is higher. For these trees, treat clumps of stems having a unified crown and common root stock as a single tree; examples include mesquite, bigtooth maple, juniper, and mountain mahogany. Treat stems of woodland species such as Gambel oak and bigtooth maple as individual trees if they originate below the ground.

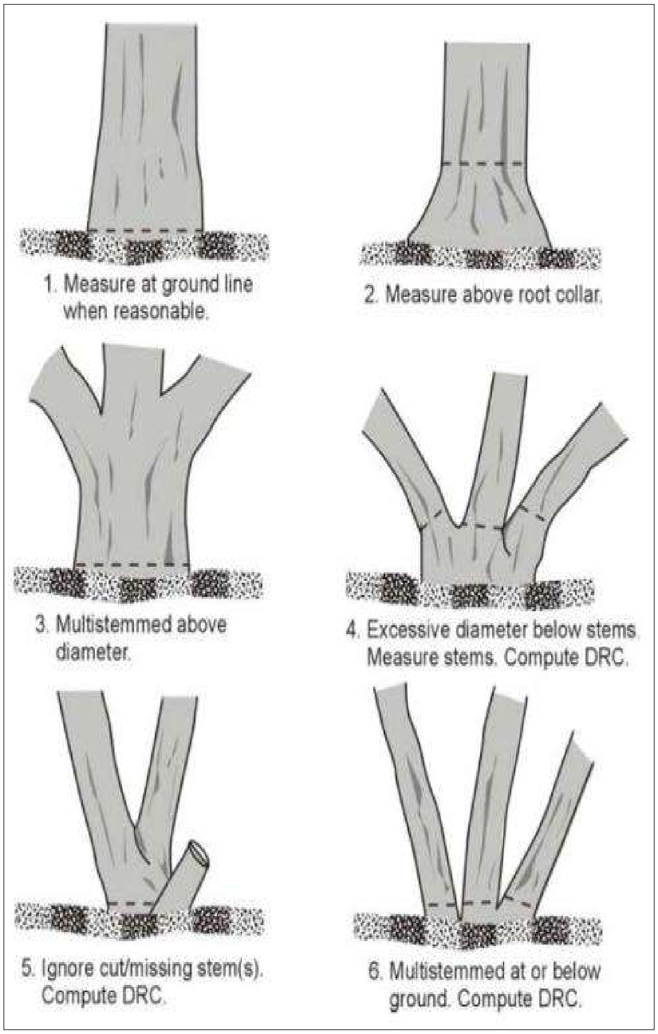
Measuring woodland stem diameters: Before measuring DRC, remove the loose material on the ground (e.g., litter) but not mineral soil. Measure just above any swells present, and in a location so that the diameter measurements are a good representation of the volume in the stems (especially when trees are extremely deformed at the base). Stems must be at least 1 foot in length and at least 1.0 inch in diameter 1 foot up from the stem diameter measurement point to qualify for measurement. Whenever DRC is impossible or extremely difficult to measure with a diameter tape (e.g., due to thorns, extreme number of limbs), stems may be estimated and recorded to the nearest 1.0-inch class. Additional instructions for DRC measurements are illustrated in Figures A1 and A2.

Computing and Recording DRC: For all trees requiring DRC, with at least one stem 1 foot in length and at least 1.0 inch in diameter 1 foot up from the stem diameter measurement point, DRC is computed as the square root of the sum of the squared stem diameters. For a single-stemmed DRC tree, the computed DRC is equal to the single diameter measured.

Use the following formula to compute DRC:

$DRC = SQRT\ [SUM\ (\text{stem diameter}^2)]$
Round the result to the nearest 0.1 inch. For example, a multi-stemmed woodland tree with stems of 12.2, 13.2, 3.8, and 22.1 would be calculated as:
$DRC = SQRT\ (12.2^2 + 13.2^2 + 3.8^2 + 22.1^2)$
$= SQRT\ (825.93)$
$= 28.74$
$= 28.7$

If a previously tallied woodland tree was completely burned and has re-sprouted at the base, treat the previously tallied tree as dead and the new sprouts (1.0-inch DRC and larger) as part of a new tree.



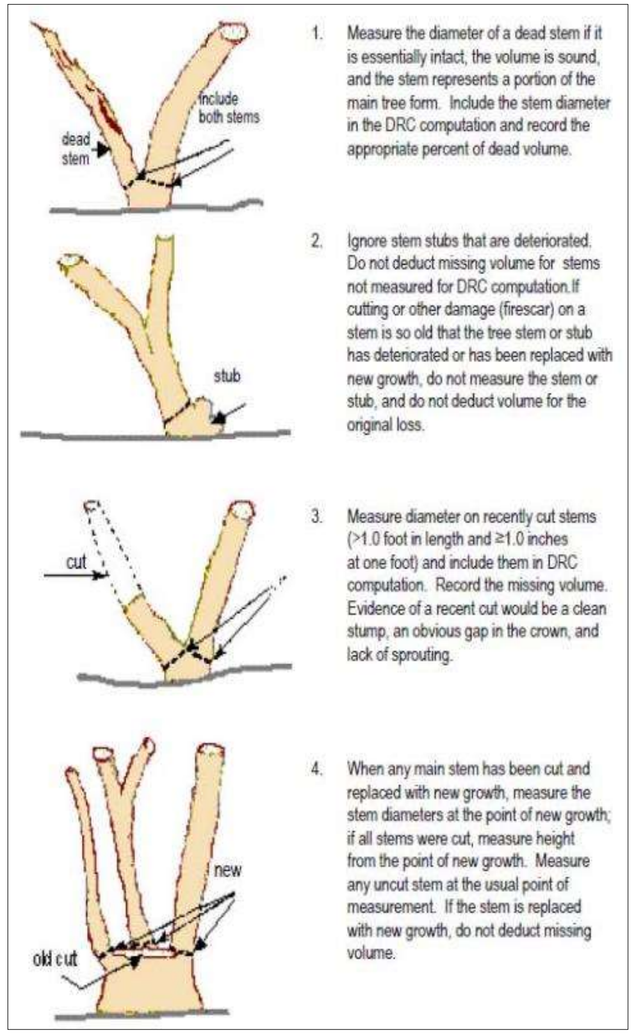


Figure A1. *How to measure DRC in a variety of situations. The cut stem in example number 5 is < 1 foot in length.*

Figure A2. *Additional examples of how to measure DRC.*

Appendix B. Veg Group, Veg Type, Canopy Cover, and Tree Size Map Unit Codes

Table B1. *Vegetation Group and Type Map Units*

Vegetation Group and Vegetation Type Map Unit	Code
Alpine	**A**
Alpine Vegetation – *inclusive of alpine shrubs*	ALP
Riparian	**R**
Riparian Herbaceous (Stream & Meadow – Wet)	RHE
Riparian Woody (Stream & Meadow – Wet)	RW
Herbland	**H**
Upland Herbaceous – inclusive of moist to dry meadows	UHE
Shrubland	**S**
Black Sagebrush	BLSB
Mountain Big Sagebrush	MSB
Mountain Shrubland	MS
Silver Sagebrush	SSB
Wyoming/Basin Big Sagebrush	WSB/BSB
Conifer Forest	**C**
Bristlecone Pine/Limber Pine	BC/LM
Douglas-fir Mix	DFmix
Spruce/Fir	SF
Ponderosa Pine	PP
Ponderosa Pine Mix	PPmix
Ponderosa Pine/Woodland	PP/WD
White Fir	WF
White Fir Mix	WFmix
Deciduous Forest	**D**
Aspen	AS
Aspen/Conifer	AS/C
Woodland	**W**
Mountain Mahogany	MM
Gambel Oak	GO
Pinyon-Juniper	PJ
Rocky Mountain Juniper Mix	RMJmix
Non-Vegetated/Sparse Vegetation	**N**
Agriculture	AGR
Barren/ Sparse Vegetation	BR/SV
Developed	DEV
Unknown	UNK
Water	WA

Table B2. *Tree Canopy Cover Map Units*

Tree Canopy Cover Map Unit	Code
10 - 19%	TC1
20 - 39%	TC2
40 - 49%	TC3
50 - 59%	TC4
≥ 60%	TC5

Table B3. *Shrub Canopy Cover Map Units*

Shrub Canopy Cover Map Unit	Code
10 - 24%	SC1
25 - 34%	SC2
≥ 35%	SC3

Table B4. *Forest Tree Size Map Units*

Forest (DBH) Tree Size Map Unit	Code
0 - 4.9”	FS1
5 - 11.9”	FS2
12 - 17.9”	FS3
18 - 23.9”	FS4
≥ 24”	FS5

Table B5. *Woodland Tree Size Map Units*

Woodland (DRC) Tree Size Map Unit	Code
0 - 5.9”	WS1
6 - 11.9”	WS2
12 - 17.9”	WS3
≥ 18”	WS4

Manti-La Sal & Fishlake NF – Field Reference Site Data Form   v. 5/14/2014

Field Reference Site Information

1- **Reference Site ID#:** _______________   *2*- **Names**: ________________________________

3- **M/D/YY:** _____-_____-_____   *4*- **Access Code:** ACC NO   *5*- **Geographic Area:** 1 2

Descriptive Plot

6- **Plot Type:** DSC   *7*- **Plot ID#:** 1

8- **Latitude:** ______________ **Longitude:** ________________ (DD WGS84) **GPS S/N** (last 4): _______ **Waypoint:** ______

9- **Field Photograph:** ______________________ **Bearing:** _______________

10- **Ocular Plot Composition**

Tree	Cover	Shrub	Cover	Herbaceous	Cover	Non-Veg Cover	
Others Combined		Others Combined		Other Grasses Combined			
				Other Forbs Combined			
Total		Total		Total		Total	
						Lifeform & Non-Veg totals must add up to 100%:	

11- **Tree Cover by DBH or DRC Diameter Class**

Tree Code	Cover	Class 1	Class 2	Class 3	Class 4	Class 5*
Others Combined						
Total						
					Tree Diameter Class totals must add up to Total % Tree Cover:	

**Forest (DBH) class only; no Woodland (DRC) class 5 exists*

12-**Dominance Type** _____________   *13*- **Veg Type MU** _____________   *14*- **Veg Group MU** _____________

15- **Canopy Cover MU** _____________   *16*- **Tree Size MU** _____________

17- **Notes:**

Tree Canopy Cover Map Unit	Code
10 - 19%	TC1
20 - 39%	TC2
40 - 49%	TC3
50 - 59%	TC4
≥ 60%	TC5

Shrub Canopy Cover Map Unit	Code
10 - 24%	SC1
25 - 34%	SC2
≥ 35%	SC3

Forest (DBH) Tree Size Map Unit	Code
0 - 4.9"	FS1
5 - 11.9"	FS2
12 - 17.9"	FS3
18 - 23.9"	FS4
≥ 24"	FS5

Woodland (DRC) Tree Size Map Unit	Code
0 - 5.9"	WS1
6 - 11.9"	WS2
12 - 17.9"	WS3
≥ 18"	WS4

Observation Plots & Site Summary

18-**Plot Type:** OBS *19*- **Plot ID#** _____

20-**Latitude:** _______________ (DD WGS84)

Longitude: _______________ **GPS S/N:**_____ **Waypt:**_____

21-**Field Photo:** ____________________ **Bearing:** _________

22-**Dom Type:** ____________ *23*- **Veg Type MU:** ____________

24-**Veg Group MU:** _______ *25*- **Canopy Cover MU:** ________

26- **Tree Size MU:** ________

27-**Notes:**

18-**Plot Type:** OBS *19*- **Plot ID#** _____

20-**Latitude:** _______________ (DD WGS84)

Longitude: _______________ **GPS S/N:**_____ **Waypt:**_____

21-**Field Photo:** ____________________ **Bearing:** _________

22-**Dom Type:** ____________ *23*- **Veg Type MU:** ____________

24-**Veg Group MU:** _______ *25*- **Canopy Cover MU:** ________

26- **Tree Size MU:** ________

27-**Notes:**

18-**Plot Type:** OBS *19*- **Plot ID#** _____

20-**Latitude:** _______________ (DD WGS84)

Longitude: _______________ **GPS S/N:**_____ **Waypt:**_____

21-**Field Photo:** ____________________ **Bearing:** _________

22-**Dom Type:** ____________ *23*- **Veg Type MU:** ____________

24-**Veg Group MU:** _______ *25*- **Canopy Cover MU:** ________

26- **Tree Size MU:** ________

27-**Notes:**

Field Reference Site Summary

28- Dom Type ____________

29- Veg Type MU

30- Veg Group MU

31- Canopy Cover MU ____________

32- Tree Size MU

33- Disturbance Event: □ Burn □ Harvest □ Other

34- Notes:

Tree Canopy Cover Map Unit	Code
10 - 19%	TC1
20 - 39%	TC2
40 - 49%	TC3
50 - 59%	TC4
≥ 60%	TC5

Shrub Canopy Cover Map Unit	Code
10 - 24%	SC1
25 - 34%	SC2
≥ 35%	SC3

Forest (DBH) Tree Size Map Unit	Code
0 - 4.9"	FS1
5 - 11.9"	FS2
12 - 17.9"	FS3
18 - 23.9"	FS4
≥ 24"	FS5

Woodland (DRC) Tree Size Map Unit	Code
0 - 5.9"	WS1
6 - 11.9"	WS2
12 - 17.9"	WS3
≥ 18"	WS4

Field Reference Site
Descriptive and Observation Plot
Tree and Shrub Transect Data Collection Protocol
4/10/2014

Tree Cover Transects: (Only for Tree life form plots.) Tree canopy cover transects are optional, but may be used by Government inspectors for quality assurance purposes.

Lay out four 50-foot transects from the plot center in each cardinal direction (200 feet of total transect). Use the same layout configuration as was used for identifying/flagging the plot boundaries from the plot center. No adjustment is made for magnetic declination. If the slope of a transect is greater than 10 percent it should already be corrected for slope and identified/flagged accordingly. Run each transect (north, east, south, and west) from the plot center to the previously identified/flagged plot boundary using tapes. Do not allow the vegetation to deflect the alignment of the tape.

Measure and record the transect intercept length (in horizontal feet) of live tree canopy cover by tree species (for all tree sizes combined: trees, saplings, seedlings). See the *Key to Forest and Woodland Dominance Types* for a list of species to include. For determining intercept length on taller or leaning trees, it may be helpful to use a densitometer to determine vertical projection of the tree crown edge. Round and record the total measured intercept length to the nearest foot for each cardinal direction. Calculate canopy cover per species and all tree species by averaging the total intercept length from the north, south, east, and west transects. Round to nearest percent.

Shrub Cover Transects: (Only for Shrub life form plots.) Shrub canopy cover transects are optional, but may be used by Government inspectors for quality assurance purposes.

Lay out four 50-foot transects from the plot center in each cardinal direction (200 feet of total transect). Use the same layout configuration as was used for identifying/flagging the plot boundaries from the plot center. No adjustment is made for magnetic declination. If the slope of a transect is greater than 10 percent it should already be corrected for slope and identified/flagged accordingly. Run each transect (north, east, south, and west) from the plot center to the previously identified/flagged plot boundary using tapes. Do not allow the vegetation to deflect the alignment of the tape.

Measure and record the number of feet of live canopy cover intercepted for each species within each 10-foot transect increment in each cardinal direction. See the *Key to Shrubland Dominance Types* for a list of species to include. Round the estimate to the nearest 0.5 foot for each 10-foot increment. Gaps within a single plant, flowers, and flower stalks should be counted as part of the shrub. Total the estimates to determine percent cover of each species for each transect. Total all shrub species percentages to determine the shrub canopy cover for each transect. Calculate the overall shrub canopy cover by averaging the total shrub cover from the north-south and east-west transects.

Field Reference Site - Descriptive and Observation Plot
Tree and Shrub Transect Data Form

1- Reference Site & Plot ID#: _______________ *2*- Names: ______________________ *3*- M/D/YY: _____-_____-_____

4- Tree Cover Transects – Horizontal Intercept Length

Plant Code	North (feet)	South (feet)	East (feet)	West (feet)	Total intercept length	Average cover (total/200')
Others Combined						
Total Timber	--	--	--	--		
Total Woodland	--	--	--	--		
Total (all tree spp)	--	--	--	--		
Total horiz. transect length	50	50	50	50	200	--

5– Shrub Canopy Cover – Horizontal Intercept Length

Transect North/South - Horizontal Distance

Plant Code	0-10'	10-20'	20-30'	30-40'	40-50'	50-60'	60-70'	70-80'	80-90'	90-100'	Total
Others Combined											

Total N/S Shrub CC ______

Transect East/West - Horizontal Distance

Plant Code	0-10'	10-20'	20-30'	30-40'	40-50'	50-60'	60-70'	70-80'	80-90'	90-100'	Total
Others Combined											

Total E/W Shrub CC ______

Overall Shrub CC ______

Appendix E: eCognition Layer Weights

Layer weights used to develop the modeling units (segments) in eCognition software

Layer	Weight
Landsat 8 OLI 2013 – 1st Principal Component	1
Landsat 8 OLI 2013 – 2nd Principal Component	1
Landsat 8 OLI 2013 – 3rd Principal Component	1
Landsat 8 OLI 2013 – NDVI	2
Landsat 8 OLI 2013 – Band 8 (Panchromatic)	7
NAIP 2011 (10-meter) – Band 1 (Red)	4
NAIP 2011 (10-meter) – Band 2 (Green)	6
NAIP 2011 (10-meter) – Band 3 (Blue)	4
NAIP 2011 (10-meter) – Band 4 (NIR)	4
NAIP 2011 (10-meter) – NDVI	8
Slope-aspect transformation cosine	4
Slope-aspect transformation sine	4

Appendix F: Tree Size Class Modeling Data Layers

Additional data layers used in the modeling of tree size

Data Source	# of Layers	Spatial Resolution	Description	Statistics Used	Total # of Predictors
ifSAR	1	5m	Estimate of canopy height	Mean, Maximum and Standard Deviation	3
Vegetation Type Map	1	10m	Mid-level existing vegetation map	Majority	1

Appendix G: Draft Map Review

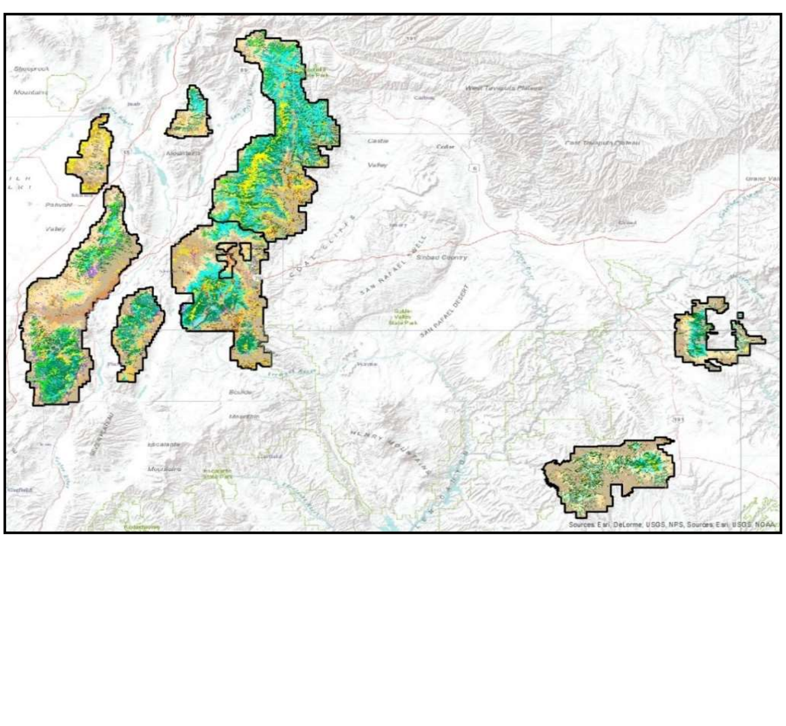
MANTI-LA SAL/FISHLAKE NATIONAL FORESTS
EXISTING VEGETATION MAPPING PROJECT – DRAFT MAP REVIEW
January 26 – February 12, 2016

Background:

The Remote Sensing Applications Center (RSAC) was tasked by the Manti-La Sal and Fishlake National Forest and Intermountain Region to develop a set of mid-level existing vegetation maps. Existing vegetation is the plant cover, or floristic composition and vegetation structure, occurring at a given location at the current time (Nelson et al. 2015). This should not be confused with Potential Natural Vegetation (PNV) which describes the vegetation communities that would be established if all successional sequences were completed without interference by man under the present climatic and edaphic conditions (Tuxen 1956). The final map products for this project will include existing vegetation type, canopy cover, and tree size class.

The project has utilized remote sensing techniques and field data to map existing vegetation types. During this process, RSAC has worked with the Forests and the Regional Office to collect and develop the data layers required for implementing semi-automated remote sensing techniques. High resolution aerial imagery collected in 2011 was used to create “mapping segments" (GIS polygons) from a combination of spectral information and physical characteristics of the landscape. These segments were then assigned a vegetation type, canopy cover, and tree size class using an ensemble classifier. The features on the draft maps have been aggregated to 2 acres for riparian types and 5 acres for upland types. The final maps will be produced at a 1:100,000 scale.

This draft map review meeting is to solicit feedback from knowledgeable staff members who can evaluate the maps and provide input for making corrections and alterations. Map revisions will be based almost entirely on the information provided from the review process. Digital maps are available via Webmap.



Vegetation type map units:

Not all vegetation types have been mapped in each district. The reference sites were reviewed at the beginning of the modeling process and the vegetation types to be depicted on the draft map were finalized. The acres of the vegetation types found in each district are listed in Appendix A & B. The Teasdale portion of the Fremont Ranger District was not included in the acreage summaries.

Vegetation Type	Fishlake NF		Manti-La Sal NF	
	Acres	%	Acres	%
Aspen	93,949	6.13%	167,440	11.85%
Aspen/Conifer	100,462	6.55%	117,220	8.30%
Douglas-fir Mix	45,057	2.94%	59,363	4.20%
Ponderosa Pine	0	0.00%	23,945	1.69%
Ponderosa Pine Mix	5,785	0.38%	4,718	0.33%
Ponderosa Pine/Woodland	0	0.00%	58,752	4.16%
White Fir	14,242	0.93%	8,105	0.57%
White Fir Mix	55,180	3.60%	23,746	1.68%
Spruce/Fir	107,029	6.98%	105,917	7.50%
Bristlecone Pine/Limber Pine	13,828	0.90%	26,951	1.91%
Mountain Mahogany	65,418	4.27%	9,066	0.64%
Pinyon-Juniper	374,061	24.40%	351,221	24.85%
Rocky Mountain Juniper Mix	1,171	0.08%	754	0.05%
Gambel Oak	249,626	16.28%	190,866	13.51%
Mountain Big Sagebrush	165,297	10.78%	73,067	5.17%
Wyoming/Basin Big Sagebrush	76,682	5.00%	3,032	0.21%
Silver Sagebrush	2,205	0.14%	1,414	0.10%
Black Sagebrush	19,384	1.26%	21,762	1.54%
Mountain Shrubland	14,707	0.96%	43,278	3.06%
Alpine Vegetation	1,873	0.12%	740	0.05%
Upland Herbaceous	91,146	5.95%	81,032	5.73%
Riparian Woody	10,421	0.68%	8,143	0.58%
Riparian Herbaceous	4,334	0.28%	2,975	0.21%
Agriculture	827	0.05%	316	0.02%
Barren/Sparse Vegetation	14,855	0.97%	25,925	1.83%
Developed	544	0.04%	283	0.02%
Water	4,994	0.33%	3,113	0.22%
Total	**1,533,077**	**100.00%**	**1,413,144**	**100.00%**

Canopy cover map units:

A canopy cover class is assigned to all areas classified as tree and shrub lifeforms on the draft version of the vegetation type map. Areas classified as *upland tree* on the draft Manti-La Sal and Fishlake National Forest Vegetation Type Map received a tree cover map unit based on the total tree cover as viewed from above, discounting overtopped trees. *Upland tree* lifeforms include all forest and woodland map units except for the *riparian woody* (RW) class. Areas classified as *shrub* and *riparian woody* receive a shrub cover map unit based on the *total shrub* cover as viewed from above, discounting overtopped shrubs. For example, a cottonwood dominance type was assigned to the RW map unit; therefore a shrub canopy cover map unit was assigned. The acres of the canopy cover classes found in each district are listed in Appendix C and D. The Teasdale portion of the Fremont Ranger District was not included in the acreage summaries.

Canopy Cover	Fishlake NF		Manti-LaSal NF	
	Acres	%	Acres	%
NC	118,573	7.73%	114,384	8.09%
SC1 (10 - 24%)	157,222	10.26%	101,003	7.15%
SC2 (24 - 34%)	49,348	3.22%	8,210	0.58%
SC3 (≥ 35%)	71,700	4.68%	21,949	1.55%
SC1r (10 - 24%)	622	0.04%	532	0.04%
SC2r (24 - 34%)	202	0.01%	11,569	0.82%
SC3r (≥ 35%)	9,597	0.63%	7,433	0.53%
TC1 (10 - 19%)	154,998	10.11%	198,345	14.04%
TC2 (20 - 39%)	558,510	36.43%	464,353	32.86%
TC3 (40 - 49%)	185,761	12.12%	202,025	14.30%
TC4 (50 - 59%)	131,496	8.58%	150,065	10.62%
TC5 (≥ 60%)	95,050	6.20%	133,275	9.43%
Total	**1,533,078**	**100.00%**	**1,413,144**	**100.00%**

Tree size map units:

Tree size class is assigned to all areas classified as tree lifeform on the draft version of the vegetation type map. Individual tree size classes are determined by comparing the total tree canopy cover percentages for each tree size diameter class within a given area (mapping polygon). Tree size class is then determined as the class containing the plurality of cover. Tree diameter is estimated at breast height (DBH) for timber species, and, at root collar (DRC) for woodland species. Timber species less than 4.5 feet tall or woodland species less than 1.0" diameter at root collar are included in the smallest tree diameter classes for each tree type respectively. Plurality of class cover is determined by comparing percent cover by diameter class as if you were looking down on the stand from above—i.e. do not double count canopy layers that are overlapping when viewed from above. For example, smaller sized trees that are being overlapped by larger ones are ignored and not counted in the diameter class estimate. The acres of the tree size classes found in each district are listed in Appendix E & F. The Teasdale portion of the Fremont Ranger District was not included in the acreage summaries.

Tree Size Class	Fishlake NF		Manti-La Sal NF	
	Acres	%	Acres	%
FS1 (0 - 4.9" dbh)	8,010	0.52%	17,518	1.24%
FS2 (5 - 11.9" dbh)	350,753	22.88%	362,782	25.67%
FS3 (12 - 17.9" dbh)	76,371	4.98%	207,951	14.72%
FS4 (18 - 23.9" dbh)	65	0.00%	7,856	0.56%
FS5 (≥ 24" dbh)	328	0.02%	51	0.00%
WS1 (0 - 5.9" drc)	248,697	16.22%	221,240	15.66%
WS2 (6 - 11.9" drc)	426,750	27.84%	211,194	14.94%
WS3 (12 - 17.9" drc)	7,094	0.46%	113,236	8.01%
WS4 (≥ 18" drc)	7,744	0.51%	6,236	0.44%
NS (No Size Class)	407,266	26.57%	265,080	18.76%
Total	**1,533,078**	**100.00%**	**1,413,144**	**100.00%**

Manti La Sal and Fishlake NF DRC Measured Woodland Species

JUOS	Juniperus osteosperma	Utah juniper
JUSC2	Juniperus scopulorum	Rocky Mountain juniper
ACGR3	Acer grandidentatum	bigtooth maple
CELE3	Cercocarpus ledifolius	curlleaf mountain mahogany
PIED	Pinus edulis	common pinyon
PIMO	Pinus monophylla	singleleaf pinyon
QUGA	Quercus gambelii	Gambel oak

Review Process:

For the review, provide as much information about the draft maps as possible. Overall, it is important to focus your attention on the general vegetation patterns and distribution of vegetation types, canopy cover, and tree size. We need information on what is correct and what is incorrect. Please remember this is a mid-level map (1:100,000 scale) and not a site map or a project level mapping effort. The minimum size of an area that will be depicted on the final map is 5 acres for upland types and 2 acres for riparian types. This is not project level mapping; fine scaled vegetation patches or stands will not be represented on the final map.

It is important to follow the "Manti La Sal/Fishlake Vegetation Key" when determining the vegetation type map unit. This ensures that everyone is assigning types based on the same rules and descriptions.

In general, the draft map review process includes the following phases:

- Review the forest and district proportion summaries provided in this procedure.
- Review the entire district. Focus on general vegetation distribution and patterns and determine if the overall community types that you see are represented.
- Next focus on specific areas that you are most familiar with. These include areas that you have done more detailed project work on or localized studies.
- If necessary follow up with field visits to areas that are confused and correct labels cannot be easily determined.

Digital versions of the draft map are available through webmap. It is important to review the general distribution and extent of vegetation patterns at a scale that corresponds to the midlevel mapping scale, e.g. 1:50,000 to 1:100,000. To access the map layers using webmap use the following directions.

- Vegetation type → http://166.2.126.153/vegmaps/MLFL_Vegetation_Type/
- Canopy cover →http://166.2.126.153/vegmaps/MLFL_Canopy_Cover/
- Tree Size webmap →http://166.2.126.153/vegmaps/MLFL_Tree_Size/

Webmap Interface:

Paste the URLs above into a browser window or hold down the **Ctrl + Click** to follow the link. A web browser will open and the map will be displayed automatically. There are four buttons at the top of the screen in the title ribbon, just to the right of center. These buttons from left to right are: **Layer List**, **Legend**, **Edit**, and **Identify**.

- The **Layer List** allows you to turn on/off the Draft Map and/or the Edits polygons. To change the **Transparency** of either of these two layers, you can click the down-arrow next to the layer in the list and select **Transparency**. Clicking and dragging along the bar allows you make the layer 0% to 100% transparent.

- The **Legend** can be activated and deactivated by clicking on legend icon. It is recommended to resize the legend so that all veg types can be seen simultaneously if your screen resolution allows.
- The **Edit** button allows you to draw polygons representing desired changes to the map.
- The **Identify Widget** allows you to click on the map, using the point select option, and it returns the class of your query position.

- Navigation tools (**zoom**, **pan**, etc.) can be found on the upper-left hand portion of the screen
- You can also change the backdrop by clicking the **Basemap** options in the top right portion of the screen. Here, you can change from imagery to street maps, terrain maps, etc.
- The **More…** tab in the top right, to the left of the **Basemap**, also allows you to see switch on/off the visibility of individual layers and adjust their transparency.

<u>Making edits to the map</u>

The **Edit** tool is used to draw polygons in order to highlight areas on the map you believe need revision. To begin making edits, click on the **Edit** button at the top of the screen, in the title ribbon. Select the map unit that you wish to place on the map (what you want to edit the map *to*). Begin drawing a polygon around the area of concern. *Be deliberate and do not rush your vertex placement* – the webmap service will not register vertices placed too rapidly. Double-click to complete the polygon. Subsequently, a window will pop up that allows you to either **Delete** the polygon or **Attribute** the polygon with your name (or initials) and add your **Comments**.

There are a number of tools at the bottom of the **Edit** window that allow you to manipulate polygons that are already drawn. The **Eraser** allows you to clear your selection. The **X** allows you to delete your selected feature. The **Create Options** drop down list allows you to select the type of polygon to edit (i.e. **Freehand**, **Point-to-Point**, **Circle,** etc.). The **Scissors** allows you to cut polygons into multiple parts based on placed vertices. The **Split Polygons** tool allows you to split the polygon in two. The **Reshape Polygons** tool allows you to reshape your polygons. The **Undo** and **Redo** tools allow you to undo and redo any edits you make.

*All edits made will save automatically when you close your webmap session.

District Questions & Observations:

This section provides specific questions and observations about the vegetation type map for each district.

<u>General:</u>

- How does the *Bristlecone Pine/Limber Pine* class seem to be represented on the map?
    - Too little?
- Is the *Rocky Mountain Juniper Mix* class accurately depicted on the map?

    - According to the acreage summary, there isn't much
- Is most of the sagebrush in this district *Wyoming/Basin Big Sagebrush?*
    - Look at distribution of *Mountain Big* versus *Wyoming/Basin Big Sage*
- Is there any *Black Sage* in the Beaver and Fillmore Ranger Districts?

<u>Ferron Ranger District</u>

- Are there more stands of MM in the district than you see in the tables?

<u>Price Ranger District</u>

- What about the Mountain Shrub (MS) mapped in the Terry Flat area, Is this sage dominated or is Mountain Shrub depicting the area correctly?
- In the Bennion Creek area there is a large area of Mountain Mahogany mapped. Is the mapping of this class in the area reasonable?

<u>Sanpete Ranger District</u>

- Between North Fork Pleasant Creek and Blue Slide Fork the area has been mapped as Mountain Shrub, does this seem reasonable?
- The district is geographically narrow, are there any vegetation classes you don't see mapped that should be?

<u>Moab Ranger District:</u>

- Most of the high elevation areas in the La Sal Mountains have been classified as Spruce/Fir. However, there are some areas of Douglas-fir Mix. Does this seem right?
- Most of the Ponderosa Pine and Ponderosa Pine/Woodland occurs along the east side of the district, around Carpenter Ridge and Buckeye Reservoir. Is this correct?
- Do the alpine areas look reasonable?
- Do the riparian areas look reasonable? There were very few reference sites available, had to do a lot of photo-interpreting for these areas. There may be confusion between oak & riparian, specifically along Beaver Creek in the La Sal Mountains.

<u>Monticello Ranger District:</u>

- Is mountain shrubland over mapped on the Abajos?
- No alpine was mapped, is it present?
- There was a lot of Ponderosa Pine and Ponderosa Pine/Woodland mapped. Does this look reasonable?
- The north-east corner (Peters Point Ridge-Bridge Canyon) there was some confusion between PJ and sagebrush. Does this area look OK?
- Do the riparian areas look reasonable? There were very few reference sites available, had to photo-interpret these areas.

<u>Beaver Ranger District:</u>

- How are the *Alpine* areas mapped in the Tushar Mountains?
    - Is there too much? Too little?
    - Mostly *Barren/Sparse Vegetation* above continuous treeline

- Is it accurate that there is nearly no *Black Sage* in the Beaver District?
- Does the extent of the *Mountain Shrub* look reasonable?
- How does the map look in the mixed conifer areas in the northern part of the district, just south of I-70?

Fillmore Ranger District:

- How do the burned areas look (primarily in the Canyon Mountains)? Most of it is coming out as *Gamble Oak* regen
- Is it appropriate to have patches of *White Fir Mix* and *Douglas-fir Mix* mapped in the Canyon Mountains?
- Lots of *Upland Herbaceous* was mapped in this district, is that accurate?
- How does the distribution of the *Mountain Mahogany* class look? Mostly on the Eastern side of the Pavani Range.
- Are there any areas that should be classified as true *Alpine* in this district?

Richfield Ranger District (Monroe Mountains):

- How do the Relative distributions of the conifer classes look? Primarily *White Fir Mix* and *Douglas-fir Mix*
- Is there any *Ponderosa Pine Mix* on Monroe Mountain?
- How does the extent and area of the *Black Sage* class look?

Richfield (San Pitch Mountains):

- A large part of the district burned last fire season, what vegetation successions have been observed in in the field on those fire scars?
- How does the extent and area of the *Black Sage* class look?

○

References:

Nelson, M.L.; Brewer, C.K.; Solem, S.L., eds. 2015. Existing vegetation classification, mapping, and inventory technical guide, version 2.0 Gen. Tech. Rep. WO-90. Washington, DC: U.S. Department of Agriculture, Forest Service, Ecosystem Management Coordination Staff. 210 p.

Tuxen, R. 1956. Die heutige naturliche potentielle Vegetation als Gegenstand der vegetation-skartierung. Remagen. Berichtze zur Deutschen Landekunde. 19:200-24

Appendix H: Merge Rules for Segments Less than MMF Size

Vegetation Types:

- Aspen AS
- Aspen/Conifer AS/C
- Douglas-fir Mix DFmix
- Ponderosa Pine PP
- Ponderosa Pine Mix PPmix
- Ponderosa Pine/Woodland PP/WD
- White Fir WF
- White Fir Mix WFmix
- Spruce/Fir SF
- Bristlecone Pine/Limber Pine BC/LM
- Mountain Mahogany MM
- Pinyon-Juniper PJ
- Rockey Mtn Juniper Mix RMJmix
- Gambel Oak GO
- Mountain Big Sagebrush MSB
- Wyoming Big Sagebrush/ Basin Big Sagebrush WSB/BSB
- Silver Sagebrush SSB
- Black Sagebrush BLSB
- Mountain Shrubland MS
- Alpine Vegetation ALP
- Upland Herbaceous UHE
- Riparian Woody RW
- Riparian Herbaceous RHE
- Agriculture AGR
- Barren/Sparse Vegetation BR/SV
- Developed/Urban DEV
- Water WA

Deciduous group	DEC	= AS, AS/C
Conifer group	CON	= SF, WF, WFmix, PP, PPmix, PP/WD, DFmix, BC/LM
Woodland group	WD	= PJ, RMJmix, MM, GO
Shrub group	SH	= BLSB, WSB/BSB, MSB, SSB, MS
Herbaceous group	HE	= UHE, ALP
Riparian group	RIP	= RW, RHE
Barren/Sparse Veg		= BR/SV
Other		= AGR, DEV (no minimum size, no filter, nothing filtering into it)
Water		= WA (no minimum size, no filter, nothing filtering into it)

Forest Types

Aspen

1. Aspen/Conifer
2. Ponderosa Pine Mix
3. White Fir Mix
4. Riparian Woody
5. CON
6. WD
7. SH
8. HE
9. Riparian Herbaceous
10. Barren/Sparse Vegetation

Aspen/Conifer

1. Aspen
2. CON
3. Riparian Woody
4. WD
5. SH
6. HE
7. Riparian Herbaceous
8. Barren/Sparse Vegetation

Douglas-fir Mix

1. White Fir Mix
2. Ponderosa Pine Mix
3. Spruce/Fir
4. CON
5. Aspen/Conifer
6. Aspen
7. WD
8. Riparian Woody
9. SH
10. HE
11. Riparian Herbaceous
12. Barren/Sparse Vegetation

Ponderosa Pine

1. Ponderosa Pine/Woodland
2. Douglas-fir Mix
3. White Fir Mix
4. CON
5. Aspen/Conifer
6. Aspen
7. WD
8. Riparian Woody
9. SH
10. HE
11. Riparian Herbaceous
12. Barren/Sparse Vegetation

Ponderosa Pine Mix

1. Douglas-fir Mix
2. White Fir Mix
3. CON
4. Aspen/Conifer
5. Aspen
6. WD
7. Riparian Woody
8. SH
9. HE
10. Riparian Herbaceous
11. Barren/Sparse Vegetation

Ponderosa Pine/Woodland

1. Ponderosa Pine
2. Douglas-fir Mix
3. White Fir Mix
4. CON
5. Aspen/Conifer
6. WD
7. Aspen
8. Riparian Woody
9. SH
10. HE
11. Riparian Herbaceous
12. Barren/Sparse Vegetation

White Fir

1. White Fir Mix
2. Douglas-fir Mix
3. Ponderosa Pine Mix
4. Spruce/Fir
5. Aspen/Conifer
6. CON
7. Aspen
8. WD
9. Riparian Woody
10. SH
11. HE
12. Riparian Herbaceous
13. Barren/Sparse Vegetation

Spruce/Fir

1. White fir Mix
2. Douglas-fir Mix
3. Aspen/Conifer
4. CON
5. Aspen
6. WD
7. Riparian Woody
8. SH
9. HE
10. Riparian Herbaceous
11. Barren/Sparse Vegetation

White Fir Mix

1. White Fir
2. Douglas-fir Mix
3. Ponderosa Pine Mix
4. Spruce/Fir
5. Aspen/Conifer
6. CON
7. Aspen
8. WD
9. Riparian Woody
10. SH
11. HE
12. Riparian Herbaceous
13. Barren/Sparse Vegetation

Bristlecone Pine/Limber Pine

1. White Fir Mix
2. Spruce/Fir
3. CON
4. Aspen/Conifer
5. AS
6. ALP
7. Barren/Sparse Vegetation
8. WD
9. SH
10. HE
11. Riparian Woody
12. Riparian Herbaceous

Woodlands

Mountain Mahogany

1. Pinyon-Juniper
2. WD
3. PP/WD
4. CON
5. DEC
6. SH
7. HE
8. RIP
9. Barren/Sparse Vegetation

Pinyon-Juniper

1. Rocky Mtn Juniper Mix
2. WD
3. Ponderosa Pine/Woodland
4. CON
5. DEC
6. SH
7. HE
8. RIP
9. Barren/Sparse Vegetation

Rocky Mountain Juniper Mix

1. Pinyon-Juniper
2. WD
3. Ponderosa Pine/Woodland
4. CON
5. DEC
6. SH
7. HE
8. RIP
9. Barren/Sparse Vegetation

Gambel Oak

1. WD
2. Ponderosa Pine/Woodland
3. Riparian Woody
4. SH
5. CON
6. DEC
7. HE
8. Riparian Herbaceous
9. Barren/Sparse Vegetation

Shrublands

Mountain Big Sagebrush
1. Mountain Shrubland
2. Silver Sagebrush
3. Wyoming Big Sagebrush
4. Basin Big Sagebrush
5. Black Sagebrush
6. SH
7. WD
8. HE
9. CON
10. DEC
11. RIP
12. Barren/Sparse Vegetation

Wyoming Big Sagebrush/ Basin Big Sagebrush
1. Basin Big Sagebrush
2. Black Sagebrush
3. Mountain Big Sagebrush
4. SH
5. WD
6. HE
7. CON
8. DEC
9. RIP
10. Barren/Sparse Vegetation

Mountain Shrubland
1. Gambel Oak
2. Mountain Big Sagebrush
3. SH
4. WD
5. DEC
6. CON
7. HE
8. RIP
9. Barren/Sparse Vegetation

Silver Sagebrush
1. Mountain Big Sagebrush
2. Mountain Shrubland
3. Wyoming Big Sagebrush
4. Black Sagebrush
5. SH
6. WD
7. HE
8. CON
9. DEC
10. RIP
11. Barren/Sparse Vegetation

Black Sagebrush
1. Wyoming Big Sagebrush
2. Mountain Big Sagebrush
3. Basin Big Sagebrush
4. SH
5. WD
6. HE
7. CON
8. DEC
9. RIP
10. Barren/Sparse Vegetation

Herblands

Alpine Vegetation
1. Barren/Sparse Vegetation
2. HE
3. Riparian Herbaceous
4. BC/LM
5. CON
6. DEC
7. WD
8. Riparian Woody

Upland Herbaceous
1. HE
2. Riparian Herbaceous
3. Barren/Sparse Vegetation
4. SH
5. Riparian Woody
6. WD
7. DEC
8. CON

Riparian (2 acres)

Riparian Woody (2 acres)
1. Riparian herbaceous
2. Gambel Oak
3. DEC
4. SH
5. WD
6. HE
7. CON
8. Barren/Sparse Veg

Riparian Herbaceous (2 acres)
1. Riparian Woody
2. HE
3. SH
4. WD
5. DEC
6. CON
7. Barren/Sparse Veg

Non-Vegetated

Barren/Sparsely vegetated
1. HE
2. SH
3. WD
4. CON
5. DEC
6. RIP

Canopy Cover Classes

Filtering Rules: 5 acres (except where otherwise noted)

Tree canopy 1
- Tree canopy 2
- Tree canopy 3
- Tree canopy 4

Tree canopy 2
- Tree canopy 3
- Tree canopy 1
- Tree canopy 4

Tree canopy 3
- Tree canopy 4
- Tree canopy 2
- Tree canopy 1

Tree canopy 4
- Tree canopy 3
- Tree canopy 2
- Tree canopy 1

Shrub canopy 1
- Shrub canopy 2
- Shrub canopy 3
- Shrub canopy 4

Shrub canopy 2
- Shrub canopy 1
- Shrub canopy 3
- Shrub canopy 4

Shrub canopy 3
- Shrub canopy 2
- Shrub canopy 4
- Shrub canopy 1

Riparian Woody canopy 1 (2 acres)
- Riparian Vegetation canopy 2
- Riparian Vegetation canopy 3

Riparian Woody canopy 2 (2 acres)
- Riparian Vegetation canopy 1
- Riparian Vegetation canopy 3

Riparian Woody canopy 3 (2 acres)
- Riparian Vegetation canopy 2
- Riparian Vegetation canopy 1

Tree Size Classes

Filtering Rules: 5 acres

Forest tree size 1

- Forest tree size 2
- Forest tree size 3
- Forest tree size 4
- Forest tree size 5

Forest tree size 2

- Forest tree size 3
- Forest tree size 1
- Forest tree size 4
- Forest tree size 5

Forest tree size 3

- Forest tree size 4
- Forest tree size 2
- Forest tree size 5
- Forest tree size 1

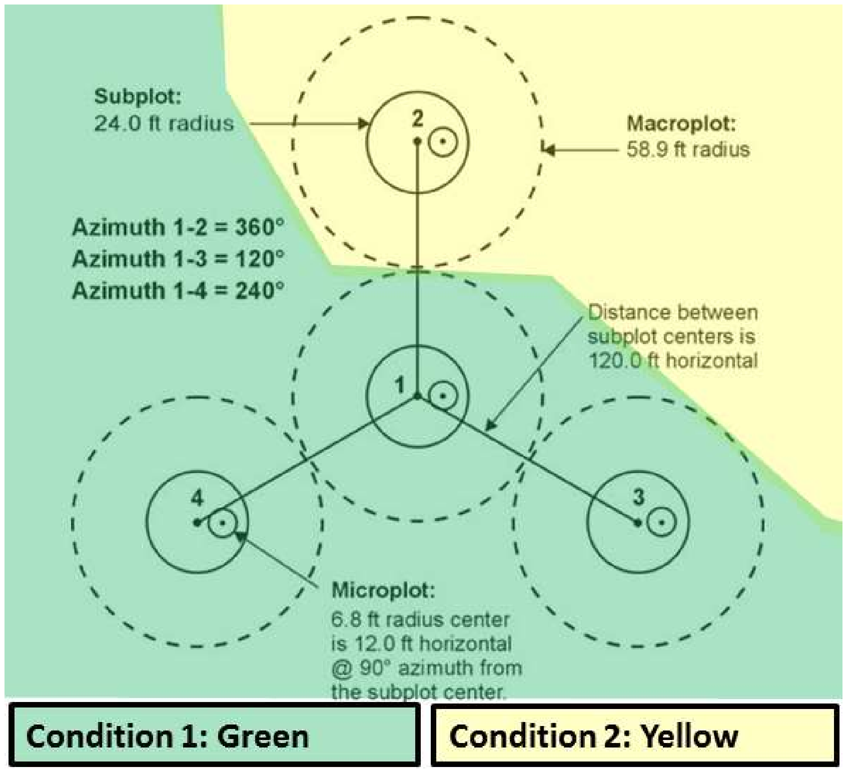
Forest tree size 4

- Forest tree size 5
- Forest tree size 3
- Forest tree size 2
- Forest tree size 1

Forest tree size 5

- Forest tree size 4
- Forest tree size 3
- Forest tree size 2
- Forest tree size 1

Appendix I: Diagram of an FIA Plot



A schematic of an FIA plot showing the four subplots. In some cases, a condition change may occur on a plot, thereby giving multiple conditions to a single plot. The schematic shows an example in which subplots 1, 3 and 4 are within condition 1, while subplot 2 is located within condition 2. Schematic source: USFS Forest Inventory and Analysis Program.